

word, while the words with high understanding when seen alone obviously did not improve much with prompting.

A question of interest related to how well does giving the same abbreviation in part 1 correlate with understanding the abbreviation in part 2. In other words, Is agreement on an abbreviation a valid predictor of understanding the abbreviation? It was found that, for those 16 words that were given by 54 percent or more of the drivers in part 1, all except 2 were understood by 85 percent or more when given with another word. The two exceptions almost reached the criteria. TEMP for temporary was at 84 percent and MOD for moderate was at 75 percent understanding. Therefore, it was concluded that highly stereotyped abbreviations would be understood with a prompt word.

This finding did not hold for the entire list of 80 words (i.e., the higher the initial stereotyping percentage, the higher the understanding percentage was not found to be true). A product-moment correlation between the two distributions yielded a value of only +0.1729. Hence, for all words, the degree of stereotyping is not a strong predictor of understanding in context. Many words with poorly stereotyped abbreviations in part 1 were found to be easily understood, especially when seen with a prompt word.

An interesting finding regarding strategy for abbreviating words was that the length of the word was a factor. For words of nine letters or more, the first-syllable strategy was employed 64 percent of the time in abbreviating. Examples are CONG for congestion and TEMP for temporary. Staff (2), who studied long meteorological words, also found that the first-syllable strategy was used for 16 of the 20 words she studied. Shorter words (5 to 7 letters) typically were abbreviated by key consonants.

There were some other interesting findings regarding the length of abbreviation. Seventy percent of the five-letter words were abbreviated in three letters and 25 percent in two letters, excluding cardinal directions. Words with six to eight letters were abbreviated in three or four letters. Words requiring five or more letters to abbreviate had very low agreement on an abbreviation, i.e., 29 percent or less. Examples were BLTWY, TRVLSR, TRNPK, FRNTG, and OVRSZ. Note that these words were

all abbreviated by the key-consonant strategy. In general, long abbreviations are not efficient and should be avoided if they exceed two-thirds of the word's length.

CONCLUSIONS AND RECOMMENDATIONS

This study identified 21 abbreviations that are understood by more than 85 percent of the drivers when the abbreviation is given alone and an additional 47 words understood by 85 percent when given with a common prompt word. These words may be considered by agencies for use on CMSs. Those that require a prompt word for understanding should be used only if the exact prompt word is used. If other words are substituted, the message should be tested before using the abbreviation.

When abbreviating new words not in the word list, the first-syllable strategy will likely result in better understanding if the word is nine letters or more. For short words of five to seven letters, the key-consonant strategy will likely lead to better understanding, although there are exceptions.

Whenever the best-understood abbreviation is longer than two-thirds of the word itself, abbreviating is discouraged. Some words cannot be efficiently abbreviated, and the agency should consider a synonym, such as FOG for reduced visibility. When the first-syllable strategy results in another word such as RED for reduced or POLL for pollution, the abbreviation should be avoided also.

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Studies of Highway Advisory Radio Messages for Route Diversion

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A series of in situ controlled field studies were conducted to establish the effectiveness of highway advisory radio (HAR) message characteristics in aiding motorists to negotiate diversion routes. The research investigated the effects of language style, message load, manner of message repetition, use of landmarks and other route descriptors, and driver familiarity with the street system. Drivers listened to simulated HAR messages while on a metropolitan Interstate and were then requested to negotiate complex diversion routes by recalling the information given. Recommendations for designing HAR messages are given based on the study findings.

Motorist information systems perform a critical role in the successful operation of real-time corridor

control systems in metropolitan areas. Flexible systems can provide information that enables drivers to use the highway system more efficiently and safely. One method that provides the flexibility to transmit a variety of information is the highway advisory radio (HAR). A HAR system is composed of a low-frequency, low-power (10- to 50-W) transmitter and an antenna that can be positioned beside a roadway to give drivers up-to-the-minute travel information via their AM radios. The number and types of messages are limited only by motorist information needs and processing capability.

In previous research (1), the Texas Transportation Institute investigated certain characteristics of HAR messages in the laboratory with the objective of developing design criteria for these messages. The laboratory findings dealt with subjects' ability to recall information under various message conditions and with subject preferences. Prior to recommending design criteria, it was first necessary to validate previous findings by investigating these message characteristics under actual driving conditions.

The experimental protocol for the series of studies reported in this paper involved selecting drivers who were generally unfamiliar with a particular diversion route. With a test administrator in the car, they would drive on a local Interstate through a metropolitan area and receive a tape-recorded HAR message. The message advised of an accident ahead and a diversion route. They would then attempt to recall pertinent guidance information in the message and drive the diversion route. The administrator recorded any errors in following the route (e.g., missed turns, turning too soon, etc). In addition, the administrator asked post-test questions, as applicable.

There were four major HAR route-diversion studies conducted in San Antonio, Texas, during summer 1980. The first was concerned with two issues: message load and language style. The second study dealt with the effects of repeating either the entire route description or parts of the description. The third study dealt with the effects of mentioning in the message easily observable landmarks, traffic signals, and businesses along the route. It was hypothesized that these route descriptors would aid the drivers by assuring them that they were still on the correct diversion route. The final study was concerned with message criteria for drivers already familiar with the street system in the area. It was assumed that familiar drivers would require less information in the message in order to follow the diversion route. [Note, these studies were part of a Federal Highway Administration (FHWA) human factors research project (2).]

STUDY 1: MESSAGE LOAD AND LANGUAGE STYLE

The first study was a joint investigation of two major variables in message design that were previously defined and investigated in the laboratory (1). These variables were message load and language style. A brief introduction to the meaning of these concepts is necessary.

Message Load

Message load, as used in this research, refers to the number of informational elements that must be recalled by the driver to successfully negotiate the route. For example, if the diversion route involved exiting the Interstate and following a parallel arterial to the right of the Interstate, the message would require, at a minimum, eight units of information:

1. Where to exit (the street name);
2. Which direction, left or right, to turn on the street;
3. Name of the parallel arterial;
4. Direction of turn--left or right;
5. Name of the return street;
6. Direction of turn;
7. Name of the Interstate; and
8. Direction of turn to reenter and continue in the original direction.

Note that message load refers here to a demand on the driver. It is possible that some of the above-listed information could be partly implied in the message without actually stating it (e.g., reentering the Interstate). Some feel that the direction of turns, although stated, are also fairly obvious given the initial turn direction from the Interstate. Nevertheless, the diversion route requires knowing eight units of stated or implied information.

Message load has been used also to refer to all information given, including the problem that necessitates diversion. In this research, only information needed to negotiate the route was included in the assessment of units of information.

Figure 1 presents the routes selected for this research. Note that a six-unit problem requires negotiating only three turns and recalling only three streets: Jackson-Keller, San Pedro, and I-410. The eight-unit problem has four turns and three street names plus I-410--a total of eight pieces of information to be learned. Similarly, the 10-unit problem has 5 turns and 5 legs, including I-410.

The experimental question was, Could a driver listen to a radio message and then recall the information sufficiently well to negotiate these routes without error, or would the longer (8- and 10-unit) routes require recall of too much information?

Language Style

In previous research (1), it was found that recalling the route was improved by simplifying the language in the message. Rather than using a long, wordy message with complete sentences and many adjectives, it was better to use a terse message that contained only the information that needed to be recalled. The wordy message was termed "conversational", an intermediate level was termed "short form", and the briefest language style was called "staccato".

In the first study, nine messages were investigated that involved three language styles in combination with three levels of message load.

Method

Subjects

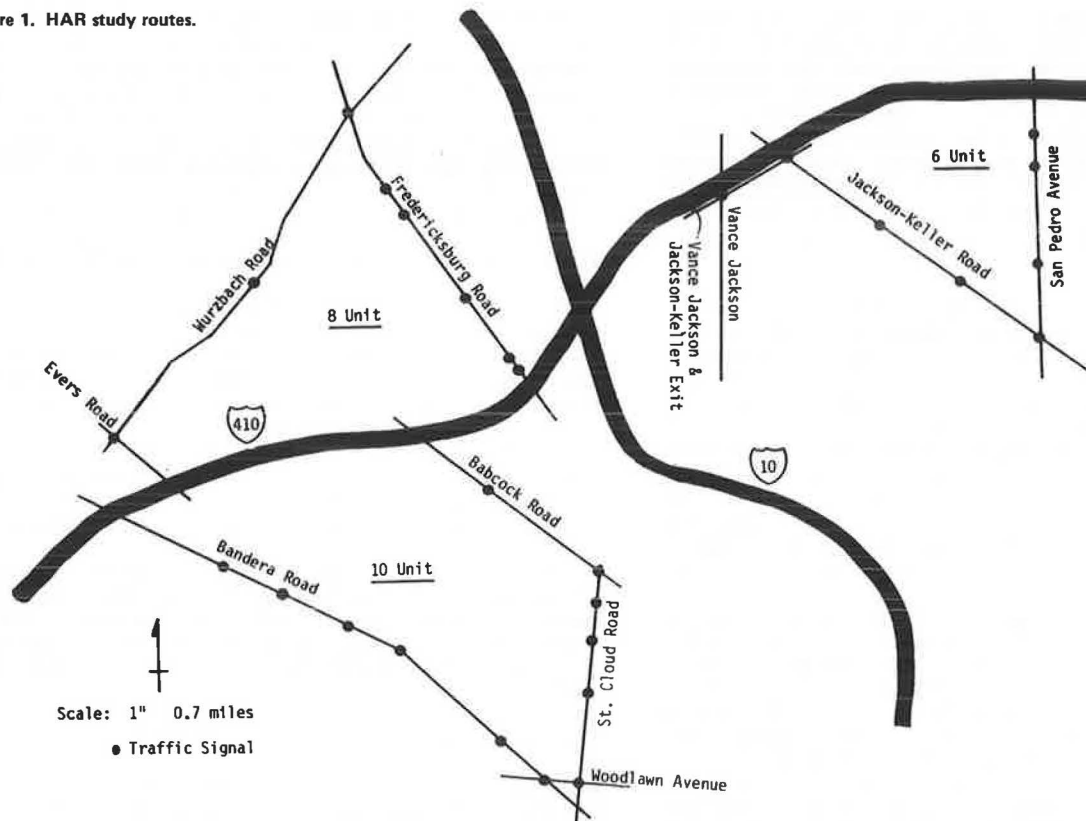
Fifty-four drivers were recruited from the San Antonio area. Each stated they were unfamiliar with the roadway system in the section of the city selected for the study. The subjects were selected to be representative of the current driving population with respect to age, sex, education, and years of driving experience.

Messages

Figures 2 and 3 present examples of messages played to the driver in study 1. Figure 2 presents three messages, all in the short-form language style. Note that they deal with the 6-, 8-, and 10-unit problems shown previously in Figure 1. The route description was repeated in each message.

Figure 3 also presents examples of language style, all for the six-unit problem. Note the key differences. For example, the staccato message states "overtaken truck ahead"; the short form states "there is an overturned truck ahead"; and the conversational style states the same plus "on Interstate 410 ahead". The conversational style also states "you are advised to exit, etc.", rather than merely "exit and take Jackson-Keller". There are other interesting but unessential words and phrases.

Figure 1. HAR study routes.



Experimental Design and Procedure

The drivers were assigned to three groups of 18 each. Each group was matched with respect to the above-mentioned demographic characteristics. Each group received messages in one of the language styles and drove three test routes that involved 6-, 8-, and 10-unit problems. The order of test routes was counterbalanced across drivers. After completing the three routes, the administrator played taped messages of all three language styles and subjects were to rank the language styles in order of preference.

Results

The table below gives the findings of the first study (note, F = frequency and % = percentage of subjects making an error):

Language Style	Message Load							
	6 Unit		8 Unit		10 Unit		Total	
	F	%	F	%	F	%	F	%
Staccato	1	6	2	11	8	44	11	41
Short form	2	11	3	17	2	11	7	26
Conversational	2	11	1	6	6	33	9	33
Total	5	18	6	22	16	60	27	100

The data given represent both frequencies of error in route negotiation and conversion of frequencies to percentages. One of the 18 drivers making an error is equivalent to approximately a 6 percent error (rounded to the nearest whole number).

It may be noted that 16 of the 27 errors (60 percent) occurred with the 10-unit problem whereas, by chance, only 9 (33 percent) would have occurred on this course. Chi-square tests found that the distribution exceeded chance probability ($p < 0.05$).

It was concluded that the 10-unit problem was more conducive to errors.

The percentage differences in language style, shown in the total column, did not differ significantly. For the 6- and 8-unit problems, errors were about the same for each style; however, for the 10-unit problem, the short form had only 2 errors while the other language styles had 14 total errors.

The table below gives the results of the preference study:

Language Style	No. of Subjects			Avg. Ranking Points
	1st Choice	2nd Choice	3rd Choice	
Staccato	17	18	19	2.04
Short form	23	21	10	1.76
Conversational	14	14	25	2.20

Twenty-three of the 54 drivers rated the short form the best style while only 10 rated it the poorest language style. The expected value in each cell was 18. Although it would be likely for drivers to prefer the language style that they had heard in the test messages, it is clear that a number of drivers preferred the short form that they had not previously heard and followed. The data provide some support for the short form and dislike for the conversational style. Because brevity in messages permits the HAR system to recycle more times within the broadcast area, the use of a terse message style is recommended.

STUDY 2: MESSAGE REPETITION

In previous research (1), a new concept was invented to describe repeating part of a message. The concept of "internal redundancy" refers to repeating the street name immediately after it is first men-

tioned in a message. Figure 4 (top) illustrates internal redundancy in a short-form version of the 10-unit problem. Note that the names Bandera, Woodlawn, St. Cloud, and Babcock are each given twice in the message.

The other technique for mentioning street names twice would be simply to give them once and then state "I repeat" and give them a second time. Figure 4 (bottom) illustrates this form of repetition, termed "external redundancy".

Method

Subjects

Eighteen drivers who had not participated in study 1 were selected for participation. They were unfamiliar with the street system and were comparable in age, sex, education, and driving experience to subjects in study 1.

Messages

The messages illustrated in Figure 4 were all in short-form language style. Messages were all in the

Figure 2. Example of message load.

Six Units

- ATTENTION EASTBOUND INTERSTATE 410 TRAFFIC
- THERE IS AN OVERTURNED TRUCK AHEAD
- TO AVOID MAJOR DELAY,
- EXIT AT JACKSON-KELLER,
- AND TAKE THE FOLLOWING ROUTE:
- TURN RIGHT ON JACKSON-KELLER,
- THEN TURN LEFT ON SAN PEDRO,
- AND PROCEED BACK TO INTERSTATE 410 WEST.

I REPEAT,

- EXIT AT JACKSON-KELLER,
- AND TAKE THE FOLLOWING ROUTE:
- TURN RIGHT ON JACKSON-KELLER,
- THEN LEFT ON SAN PEDRO,
- AND PROCEED BACK TO INTERSTATE 410 WEST.

Eight Units

- ATTENTION WESTBOUND INTERSTATE 410 TRAFFIC
- THERE IS A MAJOR ACCIDENT AHEAD
- TO AVOID MAJOR DELAY,
- EXIT AT FREDERICKSBURG,
- AND TAKE THE FOLLOWING ROUTE:
- TURN RIGHT ON FREDERICKSBURG,
- THEN LEFT ON WURZBACH
- THEN TURN LEFT AGAIN ON EVERS
- AND PROCEED BACK TO INTERSTATE 410 WEST

I REPEAT,

- EXIT AT FREDERICKSBURG,
- AND TAKE THE FOLLOWING ROUTE:
- TURN RIGHT ON FREDERICKSBURG,
- THEN LEFT ON WURZBACH,
- AND THEN LEFT AGAIN ON EVERS,
- AND PROCEED BACK TO INTERSTATE 410 WEST,

Ten Units

- ATTENTION EASTBOUND INTERSTATE 410 TRAFFIC
- THE FREEWAY IS BLOCKED AHEAD
- TO AVOID MAJOR DELAY,
- EXIT AT BANDERA,
- AND TAKE THE FOLLOWING ROUTE:
- TURN RIGHT BANDERA,
- THEN LEFT ON WOODLAWN
- THEN LEFT ON ST. CLOUD
- THEN LEFT AGAIN ON BABCOCK
- AND PROCEED BACK TO INTERSTATE 410 EAST.

I REPEAT,

- EXIT AT BANDERA,
- AND TAKE THE FOLLOWING ROUTE:
- TURN RIGHT ON BANDERA,
- THEN LEFT ON WOODLAWN,
- THEN LEFT ON ST. CLOUD,
- AND THEN LEFT AGAIN ON BABCOCK,
- AND PROCEED BACK TO INTERSTATE 410 EAST.

internal-redundant format and data were compared with that in study 1, which employed the external-redundant format. The advisory portion of the message (beginning with the word "Exit") consisted of only about two-thirds as many words as the completely repeated advisory in study 1.

Experimental Design and Procedure

Each of the 18 subjects drove a 6-, 8-, and 10-unit course as had the drivers in study 1. Procedures were identical except for the message being internally redundant.

Results

The table below gives the frequency of errors committed by the 18 subjects as compared with their counterparts in study 1 who heard the message with

Figure 3. Example of message style (six-unit diversion route).

Staccato

- ATTENTION EASTBOUND INTERSTATE 410 TRAFFIC
- OVERTURNED TRUCK AHEAD
- TO AVOID MAJOR DELAY,
- EXIT AT JACKSON-KELLER,
- TURN RIGHT ON JACKSON-KELLER,
- TURN LEFT ON SAN PEDRO,
- BACK TO INTERSTATE 410 WEST.

REPEAT,

- EXIT AT JACKSON-KELLER,
- TURN RIGHT ON JACKSON-KELLER,
- LEFT ON SAN PEDRO,
- BACK TO INTERSTATE 410 WEST.

Short Form

- ATTENTION EASTBOUND INTERSTATE 410 TRAFFIC
- THERE IS AN OVERTURNED TRUCK AHEAD
- TO AVOID MAJOR DELAY,
- EXIT AT JACKSON-KELLER,
- AND TAKE THE FOLLOWING ROUTE:
- TURN RIGHT ON JACKSON-KELLER,
- THEN LEFT ON SAN PEDRO,
- AND PROCEED BACK TO INTERSTATE 410 EAST

I REPEAT

- EXIT AT JACKSON-KELLER,
- AND TAKE THE FOLLOWING ROUTE:
- TURN RIGHT ON JACKSON-KELLER
- THEN LEFT ON SAN PEDRO,
- AND THEN LEFT AGAIN ON EVERS,
- AND PROCEED BACK TO INTERSTATE 410 EAST.

Conversational

- ATTENTION EASTBOUND INTERSTATE 410 LOP
- THERE IS AN OVERTURNED TRUCK ON INTERSTATE 410 AHEAD.
- TO AVOID MAJOR DELAY,
- YOU ARE ADVISED TO EXIT AT JACKSON-KELLER ROAD
- AND TAKE THE FOLLOWING ROUTE:
- TURN RIGHT ON JACKSON-KELLER ROAD
- AND CONTINUE TO SAN PEDRO AVENUE
- THEN TURN LEFT
- AND DRIVE BACK TO INTERSTATE 410
- TO CONTINUE YOUR EASTBOUND TRIP

I REPEAT,

- YOU ARE ADVISED TO EXIT AT JACKSON-KELLER
- AND TAKE THE FOLLOWING ROUTE:
- TURN RIGHT ON JACKSON-KELLER
- AND CONTINUE TO SAN PEDRO AVENUE
- THEN TURN LEFT
- AND DRIVE BACK TO INTERSTATE 410
- TO CONTINUE YOUR EASTBOUND TRIP.

complete repetition of the route description:

Type of Redundancy	No. of Errors by Message Load	Total Errors		
	6 Unit	8 Unit	10 Unit	
Internal	1	1	2	4
External	2	3	2	7
Total errors	3	4	4	11

It may be recalled that the fewest errors in study 1 also occurred with the short form and, hence, substantial improvement was not possible. The differences in errors were not statistically significant. The only conclusion possible from the study is that the techniques of redundancy were equally effective under the conditions of investigation.

STUDY 3: MESSAGE ROUTE DESCRIPTORS

In describing to others a particular route within a metropolitan area, a person often mentions landmarks or prominent environmental features that can be seen at a great distance and can be used either to confirm that one is on the correct route or to prepare the driver to turn. Examples of landmarks are a store, service station, or hospital. Also, the

Figure 4. Examples of internal and external redundancy in an HAR message for a 10-unit problem.

- Example - Internal Redundancy
- ATTENTION EASTBOUND INTERSTATE 410 TRAFFIC
 - THE FREEWAY IS BLOCKED AHEAD
 - TO AVOID MAJOR DELAY,
 - EXIT AT BANDERA
 - AND TAKE THE FOLLOWING ROUTE:
 - TURN RIGHT ON BANDERA
 - AND CONTINUE TO WOODLAWN
 - TURN LEFT ON WOODLAWN,
 - AND CONTINUE TO ST. CLOUD
 - THEN TURN LEFT ON ST. CLOUD
 - AND CONTINUE TO BABCOCK
 - AND THEN TURN LEFT AGAIN ON BABCOCK
 - AND PROCEED BACK TO INTERSTATE 410 EAST
- Example - External Redundancy
- ATTENTION EASTBOUND INTERSTATE 410 TRAFFIC
 - THE FREEWAY IS BLOCKED AHEAD
 - TO AVOID MAJOR DELAY,
 - EXIT AT BANDERA,
 - AND TAKE THE FOLLOWING ROUTE:
 - TURN RIGHT AT BANDERA
 - TURN LEFT AT WOODLAWN
 - LEFT AT ST. CLOUD
 - LEFT AGAIN AT BABCOCK
 - AND PROCEED BACK TO INTERSTATE 410 EAST
- I REPEAT,
- EXIT AT BANDERA,
 - AND TAKE THE FOLLOWING ROUTE:
 - TURN RIGHT AT BANDERA
 - TURN LEFT AT WOODLAWN
 - LEFT AT ST. CLOUD
 - LEFT AGAIN AT BABCOCK
 - AND PROCEED BACK TO INTERSTATE 410 EAST

Figure 5. Message with route descriptors.

- 10-Unit Route
- ATTENTION EASTBOUND INTERSTATE 410 TRAFFIC
 - THE FREEWAY IS BLOCKED AHEAD
 - TO AVOID MAJOR DELAY,
 - EXIT AT BANDERA
 - AND TAKE THE FOLLOWING ROUTE:
 - TURN RIGHT ON BANDERA
 - AND CONTINUE TO THE SIXTH TRAFFIC LIGHT, WOODLAWN
 - THERE IS A WESTERN AUTO STORE ON THE LEFT AT WOODLAWN
 - TURN LEFT ON WOODLAWN
 - AND CONTINUE TO ST. CLOUD
 - TURN LEFT ON ST. CLOUD AND GO THE THE FOURTH TRAFFIC LIGHT, BABCOCK
 - THE MORNINGSIDE MANOR REST HOME IS ON THE LEFT JUST BEFORE BABCOCK
 - AT BABCOCK TURN LEFT AGAIN AND PROCEED BACK TO INTERSTATE 410 EAST

number of traffic lights through which the driver passes before turning is a commonly used descriptor.

In this study, the 10-unit problem was modified to include two landmarks and two traffic light notations. The 10-unit problem was selected because study 1 found a high percentage of errors and, hence, a need for improvement.

Method

Subjects

Eighteen new drivers were recruited for participation. They matched the previous subjects in demographic characteristics and were unfamiliar with the roadway system.

Messages

Figure 5 presents the message given with route descriptors. It is a modification of the 10-unit message from study 1. It necessarily had the complete sentence structure of conversational style but has added information that could aid in route negotiation.

Experimental Design and Procedure

The procedure was the same as the previous studies except for the content of the message given.

Results

The table below shows that only 2 of the 18 subjects with the route descriptor message made an error:

Message	Subjects Who Made Errors	
	No.	Percent
Route descriptors	2	11
Short form	2	11
Conversational	6	33
Staccato	9	44

This performance equalled the best performance in study 1 (the short form). A succession of binomial tests found that it was significantly better than the staccato and conversational messages in study 1 ($p < 0.05$). This finding was interesting, since the message was substantially longer than previous messages. It appears that the landmarks and number of traffic lights did help in negotiating a long route.

Several subjects reported some difficulty in counting numbers of traffic lights and were confused when the traffic lights were flashing rather than operational.

STUDY 4: DRIVER FAMILIARITY AND TURN DESCRIPTORS

Previous HAR studies (3) have shown that unfamiliar

drivers must be told the names of streets at which they must turn and also the direction of turn (i.e., left or right). However, oftentimes a vast majority of drivers are local commuters who are intimately familiar with the major streets in an area where they might be diverted.

A HAR message could be greatly simplified and shortened if the direction of turning movements was omitted from the message. Given that drivers expect to be diverted first away, then parallel, and finally back to the Interstate, the only information they would really need would be a listing of the streets where they should turn. It was postulated that familiar drivers could negotiate a 10-unit diversion route given a message such as "Take the following route: Bandera to Woodlawn, to St. Cloud, to Babcock, and back to Interstate 410 East".

Method

The method was the same as previous studies. Eighteen drivers were selected who stated they were highly familiar with the street system in the area near the study routes. They were tested on the 8- and 10-unit routes. The route description gave only the names of streets with no mention of direction of turn.

Results

The table below gives the frequency of errors in comparison with the best performance for an 8- and 10-unit problem in study 1 with unfamiliar drivers:

<u>Familiarity</u>	<u>No. of Errors by Message Load</u>	
	<u>8 Unit</u>	<u>10 Unit</u>
Familiar drivers-- no turns given	0	2
Unfamiliar drivers given turns	1	2

Only 1 of the 18 drivers made an error (and that on the 10-unit problem) while negotiating a familiar route, even without the message mentioning turns. In study 1, no group exceeded this performance, although a binomial test found no significant differences in error frequency.

It was concluded that familiar drivers may be given briefer messages that do not include turn direction. They generally do not encounter problems in following a route that requires as many as five turns and five street names.

CONCLUSIONS AND RECOMMENDATIONS

The results of four driver-performance studies indicated that error frequency was generally low with HAR descriptions of diversion routes. The frequency of drivers making errors reached its peak on trials

with a 10-unit message load. However, it was demonstrated that performance even at this level could be improved by employing a short-form language style in the message and by adding landmarks and other route descriptors.

Recommendations are as follows:

1. Although language style was not found to be critical, a terse message style was preferred by drivers. Unnecessary wordiness is inefficient in communicating messages in a HAR system.
2. If unfamiliar drivers are diverted, the routes should not exceed four turns and four names, including the Interstate (eight-unit problems).
3. The description of the diversion route should be repeated at least once, either with internal or external redundancy or with both.
4. Prominent landmarks may be mentioned in a HAR message whenever there is a risk the driver may not see the place to turn. The number of traffic lights is useful but should be avoided whenever any of the lights are flashing.
5. When the driving population is known to be largely commuters or highly familiar with the area, the route description may be shortened by omitting turn directions.

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