An Analysis of Driver Preferences for Alternative Visual Information Displays

KENNETH W. HEATHINGTON, Purdue University;
RICHARD D. WORRALL, Peat, Marwick, Mitchell and Company; and
GERALD C. HOFF, Chicago Area Expressway Surveillance Project

Several traffic information descriptors have been evaluated as to how desirable they are to drivers residing in the Chicago metropolitan area. These descriptors are messages about the conditions on a freeway and are displayed by electronic signs. Evaluated were 7 descriptors at the level of heavy congestion, 6 at the level of moderate congestion, and 6 at the level of no congestion. The messages contained descriptive information, quantitative information, and no information. For all levels of congestion, traffic information was preferred to no information about traffic conditions. For the level of heavy congestion, information about an accident having occurred and causing heavy congestion was the descriptor most preferred by respondents in the total sample. The speed descriptor ranked second (the accident descriptor ranked first) for the level of heavy congestion and first for the other two levels of congestion. The two remaining descriptors (excluding the accident descriptor) were scaled fairly high, but were less desirable than the speed descriptor. The two quantitative descriptors, delay and travel time, had relatively low scale values and were simply not desired by the respondents.

•IN THE UNITED STATES the number of urban residents increased by 30 million from 1955 to 1965 (1). During this same time, vehicle ownership in the United States increased to 85 million vehicles and transit patronage decreased by over 3 billion rides annually. The result has been increasing congestion on urban highway systems, increasing transportation costs, and increasing calls for more efficient use of existing streets and highways to counter the considerable costs of constructing new facilities. (Transit includes surface street car, bus, or trolley bus in local urban service as well as subways or elevated rail rapid transit. Public transportation includes transit plus rail commuter services and taxis. Highway facilities or highway system includes all types of facilities available for use by the automobile. The transportation system includes facilities of all modes of transportation.)

Most urban highways, and particularly freeways, operate satisfactorily for a large portion of the day, but they become extremely congested during the morning and afternoon peak periods. Even in low-density urban areas, the freeway volume carried during the morning peak period can exceed 20 percent of the total 24-hour volume (2). The inevitable result of this concentration of demand is a sharp reduction in level of service.

Although freeway facilities may be extremely overloaded at certain times, frequently other parallel elements of the highway system have low utilization during these peak periods (3). One possible method for providing a higher level of peak-period service on existing freeways, therefore, appears to be a redistribution of demand. Conceptually, this could be accomplished by mandatory controls and by voluntary choice on the part

Paper sponsored by Committee on Freeway Operations and presented at the 49th Annual Meeting.

of individual drivers. Mandatory controls enforce the use of designated routes. At the beginning of a journey, a motorist would be assigned a route, and he would be required to take the particular route designated. Voluntary choice would include the provision of information to the motorist that would enable him to select the more appropriate route for his journey. Voluntary choice, though certainly more desirable in principle, requires as an essential additional input the provision of information to the driver on the alternatives available to him and the levels of service they offer. (Information includes information on traffic and road conditions, routing, and directional guidance. Traffic information is information on speed, volume, minutes of delay, and the like associated with a given route.) In other words, a system based on voluntary choice has to give the driver a good reason for changing his route away from the freeway onto an alternate road. At present only primitive techniques are available for transmitting this type of information and are, all too often, both inaccurate and untimely. In the Chicago metropolitan area, helicopter traffic reports are broadcast over local radio stations; in isolated areas, other forms of traffic information are available.

An information system is needed, therefore, that could provide the highway user with real-time or pseudo-real-time information on the operational status of alternative highway facilities. (Real-time information is instantaneous information regarding conditions on the freeway. However, the best interests of the controlling agency or the driver may not be served by furnishing all information in real time. When it is more desirable to delay by some specific time interval the furnishing of information, the delayed information is in pseudo-real-time.) Such a system, if it can be made to work, can well offer substantial returns in terms of improved system performance.

The motorist beginning a journey usually has little or no knowledge of the operating conditions existing on any of the available routes between his origin and destination. Generally, his expectations of the conditions that are likely to prevail and of the alternatives available to him are founded solely on his previous experience. His perceived notions of the traffic conditions on any given route can be the result of several information sources such as the news media, either radio or paper, friends, or his own past driving experience. If he selects a route that is heavily congested, the journey becomes taxing for himself and serves to increase the inefficiency of overall system performance. Better alternative routes may be available to him, but he seldom has sufficient information on which to base an intelligent choice.

Once a driver has begun his journey, he may encounter congestion caused either by the heavy demand placed on his route or by the occurrence of an incident, not necessarily an accident, that causes a breakdown in flow. (An incident may be an accident or the placing of warning signs near the roadway by a road repair crew. An incident is anything that causes a breakdown in operation.) Under such circumstances some drivers will voluntarily divert to other routes to avoid the congested conditions. Others will simply remain on the preselected route. In either case, the individual driver has very little real-time information available to help him make a wise decision as to the correct procedure to follow. The provision of such information at the appropriate point along a route could, and probably would, cause a voluntary diversion of a proportion of drivers and cause in turn a shift in demand and a more rapid return to an efficient level of overall system operation.

DESIGN OF STUDY

A research study was undertaken to evaluate specific traffic information descriptors (outputs) to be used by a Freeway Driver Information System (FDIS). As conceived here, the FDIS would operate only on selected freeways and at selected locations adjacent to these freeways. It is designed to increase the efficiency of existing facilities by promoting a voluntary redistribution of demand so that new facilities do not have to be constructed. The FDIS will operate in real-time, furnishing information about traffic conditions to freeway users. Psychological scaling techniques were used to evaluate driver preferences for selected visual information displays. This research was directed toward evaluating visual displays rather than audio broadcasts; however, findings are thought to be applicable to both.

In the following discussion, the level of information refers to heavy, moderate, or uncongested traffic conditions. The form of information may be descriptive such as moderate congestion or quantitative such as the number of minutes of travel time. The method of paired comparisons used to evaluate the level and form of information preferred by drivers is described in detail in the literature (4, 5). A sample of 732 drivers residing in Cook County, Illinois, was selected, and each driver was administered a structured questionnaire to obtain responses for the paired comparison evaluation. Each driver owned a car and made a regularly scheduled automobile trip to a place of employment, school, or other location. Residences of the drivers were uniformly distributed throughout Cook County. The 7 descriptors for heavy congestion, 6 for moderate congestion, and 6 for no congestion are given in the following list:

Heavy Congestion

1. Speed 5 to 15 mph—next 3 miles
2. Heavy congestion—next 3 miles
3. Stop and go traffic—next 3 miles
4. Extra delay 10 to 20 minutes—next 3 miles
5. Accident—heavy congestion—next 3 miles
6. Travel time 15 to 25 minutes—next 3 miles
7. Blank sign

Moderate Congestion

1. Speed 20 to 30 mph—next 3 miles
2. Moderate congestion—next 3 miles
3. Heavy, steady, traffic flow—next 3 miles
4. Extra delay 0 to 10 minutes—next 3 miles
5. Travel time 5 to 15 minutes—next 3 miles
6. Blank sign

No Congestion

1. Free-flowing traffic—next 3 miles
2. Uncongested—next 3 miles
3. Extra delay 0 minutes—next 3 miles
4. Speed 45 to 55 mph—next 3 miles
5. Travel time 3 to 8 minutes—next 3 miles
6. Blank sign

Each descriptor at each level of congestion was paired with all other descriptors at that level. The respondent was told that the signs (descriptors) in each pair described the same traffic conditions on an expressway. The respondent was asked to indicate whether he preferred sign A or sign B as a form of traffic information.

The number of pairs to be compared at each level is $n(n - 1)/2$ where n is the number of descriptors. A total of 51 pairs were generated and viewed by each respondent: 21 pairs and 15 pairs each for moderate congestion and uncongested conditions. Figure 1 shows typical signs that were presented to respondents. The paired comparisons and the descriptors within each pair were randomly ordered for different respondents to avoid bias caused by respondent fatigue or the tendency of some respondents to always choose the first or second descriptor in each pair.

The messages of the descriptors contained (a) descriptive information, (b) quantitative information, and (c) no information. The descriptors giving speed, travel time, and delay information were considered to be quantitative, and the blank sign gave no information. The remaining signs gave descriptive information.

DRIVER PREFERENCES FOR DESCRIPTORS

The P'_{JK} matrix for heavy congestion, moderate congestion, and no congestion is given in Tables 1, 2, and 3 respectively. These tables give the percentage of the time

Figure 1. Typical traffic information descriptors.

TABLE 1

PERCENTAGE OF TIME DESCRIPTOR J IS PREFERRED OVER DESCRIPTOR K FOR HEAVY CONGESTION

K Descrip-tors	J Descriptors						
	1	2	3	4	5	6	7
1	–	47.59	46.32	36.97	66.71	26.49	13.31
2	52.41	–	46.74	37.11	77.05	33.29	13.74
3	53.68	53.26	–	32.86	70.82	33.43	17.71
4	63.03	62.89	67.14	–	76.35	41.08	22.95
5	33.29	22.95	29.18	23.65	–	28.05	12.46
6	73.51	66.71	66.57	58.92	71.95	–	29.32
7	86.69	86.26	82.29	77.05	87.54	70.68	–

TABLE 2

PERCENTAGE OF TIME DESCRIPTOR J IS PREFERRED OVER DESCRIPTOR K FOR MODERATE CONGESTION

K Descrip-tors	J Descriptors					
	1	2	3	4	5	6
1	–	44.33	41.93	27.20	21.25	18.98
2	55.67	–	52.97	37.82	37.82	23.37
3	58.07	47.03	–	28.75	27.20	24.50
4	72.08	62.18	71.25	–	49.72	29.18
5	78.75	62.18	72.80	50.28	–	37.68
6	81.02	76.63	75.50	70.82	62.32	–

TABLE 3

PERCENTAGE OF TIME DESCRIPTOR J IS PREFERRED OVER DESCRIPTOR K FOR NO CONGESTION

K Descrip-tors	J Descriptors					
	1	2	3	4	5	6
1	–	43.06	18.98	57.08	27.62	35.98
2	56.94	–	21.81	58.22	26.06	33.43
3	81.02	78.19	–	79.75	46.03	35.84
4	42.92	41.78	20.25	–	20.40	20.96
5	72.38	73.94	53.97	79.60	–	43.06
6	64.02	66.57	64.16	79.04	56.94	–

each descriptor J was preferred over descriptor K at a given level of congestion. For heavy traffic (Table 1), descriptor 1 (speed 5 to 15 mph—next 3 miles) is preferred over descriptor 2 (heavy congestion—next 3 miles) 52.41 percent of the time, descriptor 5 (accident—heavy congestion—next 3 miles) is consistently preferred over all other descriptors, and descriptor 7 (blank sign signifying that information is not furnished) is generally the least preferred. For all 3 levels of congestion, a blank sign is the least preferred of all the descriptors.

The P'_{JK} matrix was used to develop a ranking or scaling of the descriptors for each level of congestion. These scale values for each descriptor, shown in Figures 2, 3, and 4, have several similar characteristics. At all 3 congestion levels, the blank sign has the lowest scale value and is, therefore, taken to represent a scale value of zero. The respondents interviewed preferred some form of traffic information on expressways regardless of the level of congestion. Even when there is no congestion and traffic is free-flowing, the respondents exhibited a preference for traffic information to be displayed. This seems to indicate that drivers want to be kept informed at all times about conditions to be encountered ahead of them on an expressway.

At all 3 levels of congestion, 2 quantitative descriptors were relatively undesirable to the respondents and had little meaning to them relative to the other descriptors.

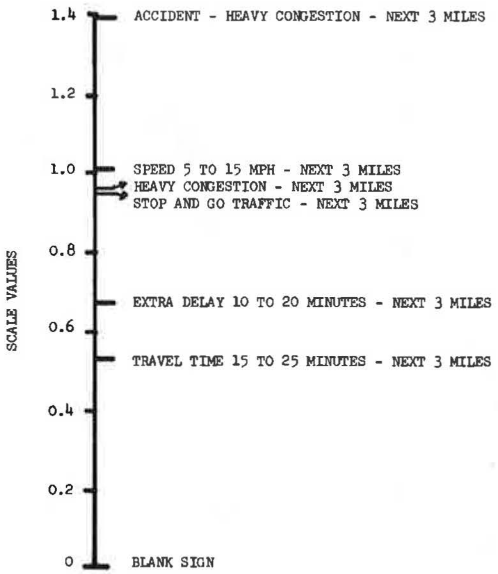

Figure 2. Scaling of descriptors for heavy congestion.

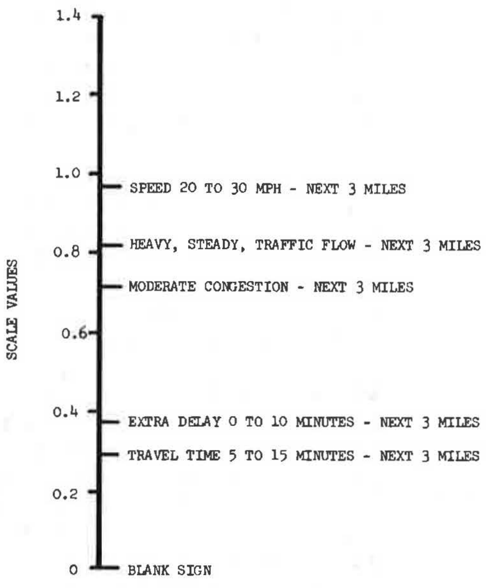

Figure 3. Scaling of descriptors for moderate congestion.

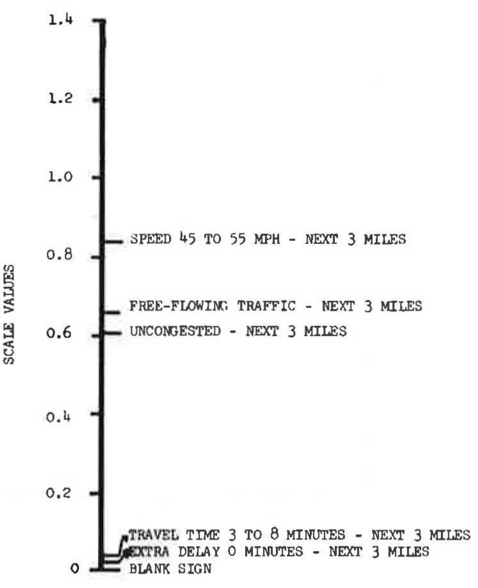

Figure 4. Scaling of descriptors for no congestion.

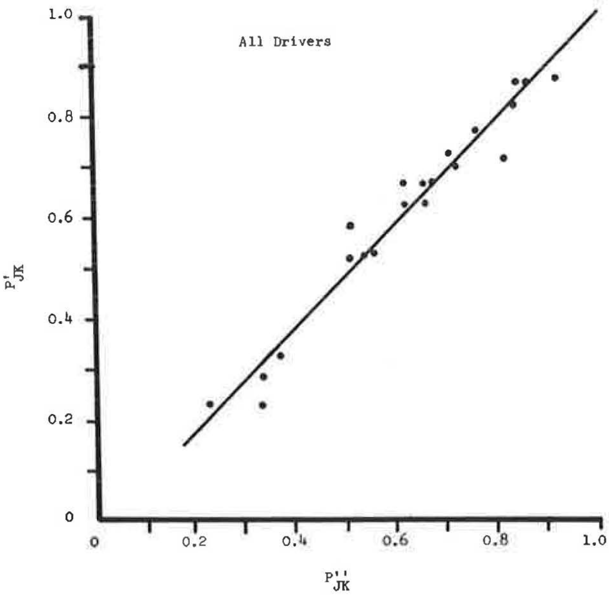

Figure 5. Calculated versus observed proportions of preference of descriptor J over K for heavy congestion.

These 2 represent minutes of travel time and delay, and their scale values at the level of no congestion (Fig. 4) are approximately equal to that of a blank sign.

For all 3 levels of congestion, the 2 descriptors pertaining to traffic conditions were preferred to the travel time, delay, and the blank sign descriptors. The traffic-condition descriptors have a relative scale value at each level of congestion that places them in the upper priority of traffic information descriptors. They are simple, concise, and easily comprehended. The driver does not have to make any mental calculations to translate them into meaningful information. It may be questionable whether a given descriptive term means exactly the same thing to each respondent, but the preferences of all respondents gave these descriptive terms relatively high priority ratings.

The quantitative term of speed was highly preferred. At the levels of moderate congestion and no congestion, it was the most preferred of all the descriptors. That the drivers interviewed scaled the speed descriptors as they did is perhaps not too surprising because all the driving experience of each respondent has been related in some form to a speedometer. The driver often measures his ability to negotiate a given route by the speed at which he can drive, rather than by the extra delay involved or the travel time required. The speedometer is always available for reference and probably is more available than a reference to time either in delay or in total travel.

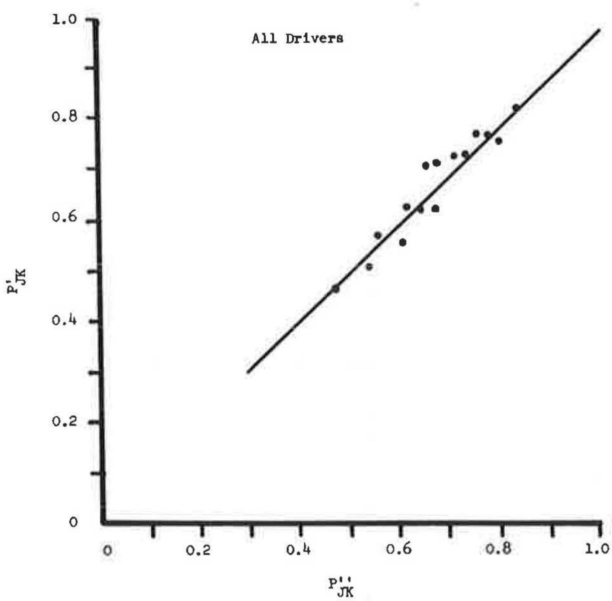

Figure 6. Calculated versus observed proportions of preference of descriptor J over K for moderate congestion.

One additional descriptor used for the level of heavy congestion informed the driver that an accident had occurred and heavy congestion was on the expressway ahead. At the level of heavy congestion, this descriptor was preferred above all other descriptors, even to the one for speed. One might intuitively suggest several reasons why respondents prefer to know that an accident

has occurred on the expressway ahead. In the Chicago area, accidents on major expressways can cause extreme congestion and long delays. Many times these accidents are minor but, because of a gapers' block by drivers going in both directions, traffic tie-ups can be extremely critical. A gapers' block is the situation where drivers slow down to a crawl speed to view an accident. The accident can be a minor or major one, but the disruption to traffic is caused not by the lanes of traffic being blocked by the accident but by drivers slowing down to view the accident. When the exit ramps are located at fairly long spacing intervals, a driver can easily become ensnared in a traffic tie-up and lose a significant amount of time. It would be difficult to imagine that anyone who has driven in the Chicago area for any length of time has escaped being in a traffic tie-up caused by an accident. One could perhaps well argue that one involvement is sufficient to cause drivers to desire information that might help them avoid such incidents. Some may argue that information on accidents would draw curiosity seekers, but the authors believe that the desire to avoid a traffic tie-up is the primary reason that drivers gave this descriptor the highest scale value.

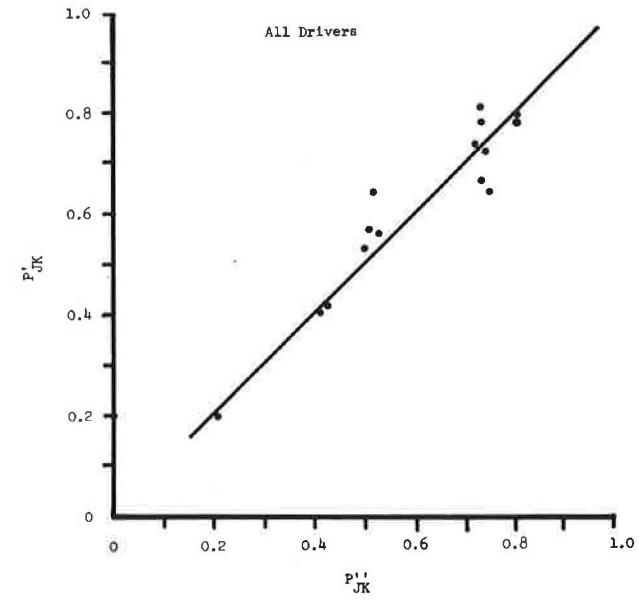

Figure 7. Calculated versus observed proportions of preference of descriptor J over K for no congestion.

EVALUATING THE MODEL

A variety of checks may be made to evaluate the internal consistency of the scaling technique. The least squares estimates of the scale values were evaluated for each level of congestion. Once the least squares estimates of the scale values are determined, a P''_{JK} matrix representing the derived percentages that descriptor J is preferred over descriptor K is formed. If the least squares estimates are unbiased, the P''_{JK} values form a linear relationship with the observed P'_{JK} entries. Figures 5, 6, and 7 show the relationship of the P''_{JK} entries to those of the P'_{JK} matrix.

The plots of the P''_{JK} and the P'_{JK} matrices indicate a fairly good fit of the model to the observed data for heavy and moderate congestion, although there is some scatter of the data for uncongested conditions. The chi-square test, however, showed the model to be statistically acceptable at all 3 levels of congestion at the 0.05 confidence level (6, 7, 8). Table 4 gives the results of the tests.

TABLE 4

RESULTS OF TEST FOR FIT OF MODEL AND OBSERVED DATA

Level of Congestion	Degrees of Freedom	Chi Square		Significant Difference
		Calculated	0.05	
Heavy	15	1.92	25.00	No
Moderate	10	0.70	18.31	No
None	10	2.29	18.31	No

ANALYSIS OF DATA BY SUBGROUPS

For each level of congestion, the sample was divided into the subgroups based on the respondents who (a) are male drivers, (b) are female drivers,

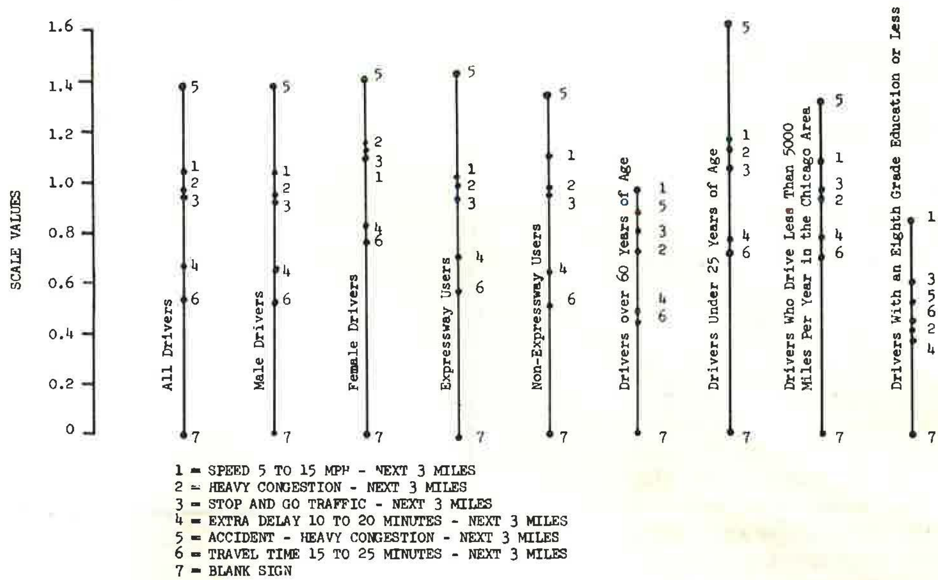

Figure 8. Scaling of descriptors for subgroups for heavy congestion.

(c) use expressway for journey to work, (d) do not use expressway for journey to work, (e) have an eighth grade education or less, (f) drive less than 5,000 miles per year in the Chicago area, (g) are under 25 years of age, and (h) are over 60 years of age. Scale values for the traffic descriptors for each level of congestion were determined for each subgroup and then compared to those of the total sample. A chi-square test was made for significant differences between each subgroup and the total sample. The

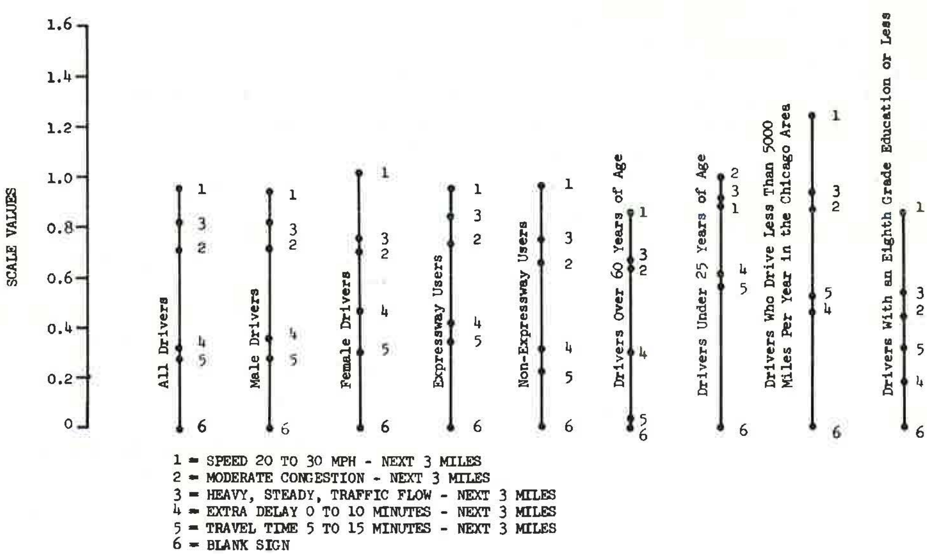

Figure 9. Scaling of descriptors for subgroups for moderate congestion.

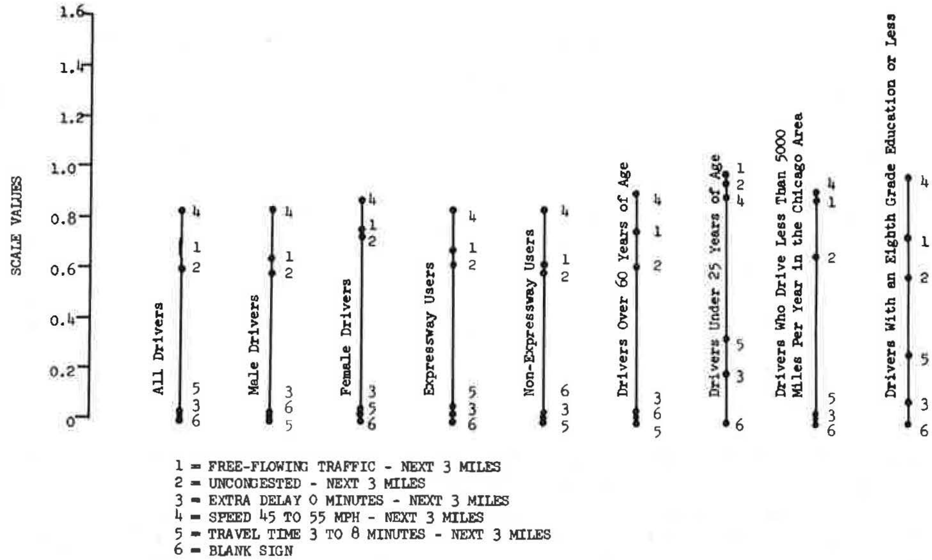

Figure 10. Scaling of descriptors for subgroups for no congestion.

scale values for the total sample and each of the subgroups for heavy, moderate, and uncongested conditions are shown in Figures 8, 9, and 10 respectively.

For the level of heavy congestion, all but 2 of the subgroups gave the highest scale values to descriptor 5 (accident—heavy congestion—next 3 miles). These 2 subgroups included respondents over 60 years of age and those with an eighth grade education or less who selected the speed descriptor as their first choice. Respondents with a low educational level selected descriptor 5 as their third choice. Respondents under 25 years of age gave this descriptor somewhat higher scale value than the other groups did. Generally, for the level of heavy congestion, the most preferred descriptor (the one with the highest scale value) was one that furnished information about an accident. Speed, a quantitative term, was usually the second choice. Speed, heavy congestion, and stop-and-go traffic were very close together, and at times, their scale values were interchanged for some of the subgroups. Two of the quantitative terms, travel time and extra delay, were of minor importance. For all of the subgroups, the blank sign received the lowest scale value of all the descriptors. The respondents, regardless of grouping, preferred information at the level of heavy congestion and were fairly consistent in their particular preferences.

For the level of moderate congestion, all but one of the subgroups gave the highest scale value to the speed descriptor. Those respondents under 25 years of age ranked speed third and moderate congestion first. Generally, for the level of moderate congestion, the descriptive terms—heavy, steady, traffic flow in descriptor 3 and moderate congestion in descriptor 2—were scaled lower than speed. The quantitative terms, extra delay and travel time in descriptors 4 and 5, ranked low in the order of preferences, and the blank sign, descriptor 6, received the lowest scale value of all the descriptors.

For the level of no congestion, all but one of the subgroups preferred the descriptor speed over all other descriptors. Again, those respondents under 25 years of age ranked speed third and free-flowing traffic first. The rest of the subgroups scaled the 2 descriptive terms, free flowing traffic in descriptor 1 and uncongested in descriptor 2, lower than speed. All subgroups valued the quantitative terms, extra delay and travel time, and the blank sign quite low.

TABLE 5

SIGNIFICANT DIFFERENCES BETWEEN SUBGROUP AND TOTAL GROUP FOR HEAVY CONGESTION

Subgroup	Number in Subgroup	Degrees of Freedom	Chi Square Calculated	Chi Square 0.05	Significant Difference
1. Are male	638	15	0.04	25.00	No
2. Are female	68	15	3.33	25.00	No
3. Use expressway	402	15	0.50	25.00	No
4. Do not use expressway	304	15	0.80	25.00	No
5. Have an eighth grade education or less	60	15	36.38	25.00	Yes
6. Drive less than 5,000 miles per year in Chicago area	71	15	3.89	25.00	No
7. Are under 25 years of age	30	15	4.95	25.00	No
8. Are over 60 years of age	55	15	9.74	25.00	No

Note: There were 706 in total group.

A chi-square test was used to ascertain any significant differences in the preference for descriptors between each subgroup and the total sample. There are some obvious limitations when the chi-square test is used in this manner. Basically, each subgroup is a subset of the total group and, depending on the individual subgroup size, will reflect the characteristics of the total sample. As the subgroup becomes large relative to the total group, these characteristics will become more dominant, and the calculated chi square value will decrease. This can result in not rejecting the null hypothesis that there is no significant difference between the subgroup and the total

TABLE 6

SIGNIFICANT DIFFERENCES BETWEEN SUBGROUP AND TOTAL GROUP FOR MODERATE CONGESTION

Subgroup	Number in Subgroup	Degrees of Freedom	Chi Square Calculated	Chi Square 0.05	Significant Difference
1. Are male	638	10	1.43	18.31	No
2. Are female	68	10	1.24	18.31	No
3. Use expressway	402	10	0.22	18.31	No
4. Do not use expressway	304	10	2.79	18.31	No
5. Have an eighth grade education or less	60	10	3.85	18.31	No
6. Drive less than 5,000 miles per year in Chicago area	71	10	2.40	18.31	No
7. Are under 25 years of age	30	10	5.99	18.31	No
8. Are over 60 years of age	55	10	0.89	18.31	No

Note: There were 706 in total group.

TABLE 7

SIGNIFICANT DIFFERENCES BETWEEN SUBGROUP AND TOTAL GROUP FOR NO CONGESTION

Subgroup	Number in Subgroup	Degrees of Freedom	Chi Square Calculated	Chi Square 0.05	Significant Difference
1. Are male	638	10	0.03	18.31	No
2. Are female	68	10	2.38	18.31	No
3. Use expressway	402	10	0.12	18.31	No
4. Do not use expressway	304	10	0.17	18.31	No
5. Have an eighth grade education or less	60	10	3.82	18.31	No
6. Drive less than 5,000 miles per year in Chicago area	71	10	2.00	18.31	No
7. Are under 25 years of age	30	10	9.55	18.31	No
8. Are over 60 years of age	55	10	1.43	18.31	No

Note: There were 706 in total group.

sample when at times perhaps it should be rejected. Therefore, the chi-square test results given in Tables 5, 6, and 7 should be used merely as indicators and not as rigid tests for significant differences.

For all 3 levels of congestion, only one subgroup appeared to differ significantly from the total sample. This was the respondents with an eighth grade education or less for level of heavy congestion.

In addition to the chi-square results given in Tables 5, 6, and 7, a plot was made of the P'_{JK} of the total group and the P'_{JK} of each subgroup. As expected, the greater the departure from linearity, the higher was the value of the calculated chi square value. Consequently, these 2 procedures complemented one another.

SUMMARY

For all levels of congestion, traffic information was preferred to no information about traffic conditions. For the level of heavy congestion, information about an accident that had occurred and was causing heavy congestion was the most preferred descriptor of the total sample. The speed descriptor ranked second to the accident descriptor for the level of heavy congestion and first for the other two levels of congestion. The 2 descriptive terms (excluding the accident descriptor) were scaled fairly high, but were less desirable than the speed term. The 2 quantitative terms, delay and travel time, had relatively low scale values and were simply not desired by the respondents.

Only a limited number of traffic information descriptors were evaluated. The method of paired comparisons can be used to extend this evaluation to any number of descriptors. Although this research was applied only to visual formats, it can be extended to audio descriptors. A desirable information format, whether audio or visual, would be one that is satisfactory to a wide range of drivers and yet will not discriminate against any particular subgroup. The capability of furnishing the desired information becomes a function of design.

ACKNOWLEDGMENTS

The U.S. Bureau of Public Roads and the Illinois Division of Highways provided funds for the data acquisition and financial support. The Department of Civil Engineering of Northwestern University provided the computer time used in this analysis. The School of Civil Engineering of Purdue University provided services for typing and reproducing the manuscript.

REFERENCES

1. Owen, Wilfred. The Metropolitan Transportation Problem. Doubleday and Company, Inc., Garden City, N.Y., 1966.
2. Heathington, K. W., and Jones, A. D. An Analysis of Peak Period Freeway Volume Characteristics. Traffic Engineering, May 1966.
3. Marks, H., and Spitz, S. A Review of Transportation Aspects of Land-Use Control, NCHRP Rept. 31, 1966.
4. Thurstone, L. L. The Measurement of Values. The Univ. of Chicago Press, 1967.
5. Torgerson, W. S. Theory and Methods of Scaling. John Wiley and Sons, Inc., New York, 1967.
6. Mosteller, Frederick. Remarks on the Method of Paired Comparisons—The Least Squares Solution Assuming Equal Standard Deviations and Equal Correlations. Psychometrika, Vol. 16, No. 1, March 1951.
7. Mosteller, Frederick. Remarks on the Method of Paired Comparisons—The Effect of an Aberrant Standard Deviation When Equal Standard Deviations and Equal Correlations Are Assumed. Psychometrika, Vol. 16, No. 2, June 1951.
8. Mosteller, Frederick. Remarks on the Method of Paired Comparisons—A Test of Significance for Paired Comparisons When Equal Standard Deviations and Equal Correlations Are Assumed. Psychometrika, Vol. 16, No. 2, June 1951.

Discussion

DONALD E. CLEVELAND, Department of Civil Engineering, University of Michigan—Various techniques can be used to serve a fixed set of traffic demands. Until recently, little attention has been given to the use of traffic information and control methods to achieve a redistribution of flows from over-utilized freeways to under-utilized major arterial streets. Under certain circumstances and as a result of this redistribution, most travel can be accomplished faster and more smoothly. The authors have contributed a valuable study that will aid in the evolution of this method and design of operating systems.

They believe that traffic redistribution should and can be accomplished by providing current information on flow conditions on alternate routes and that the message displayed is important in providing this information. They have conducted an experiment in which as many as 6 pictorial displays generally purporting to contain the same informational content were shown to 706 subjects, all of whom were Chicago area automobile owners on a pseudo-freeway. The subjects were shown displays for 3 widely varying levels of service.

Their findings show that the subjects strongly desired any information on flow conditions ahead. This desire increased as traffic conditions became more congested. The information regarding average speed was preferred generally except that under heavy traffic conditions information that an accident had occurred ahead was considered to be of more value than speed information. Generally, stratification of the subjects by sex, expressway usage habits, age, educational level, and annual local mileage showed no significant differences in these findings.

The study appears to have been well executed; the analysis techniques are satisfactory and widely used; the sample is adequate; the findings appear to be integrable with operational studies such as those we are making in Detroit in which several types of displays on alternate routes are being used. There does not seem to be any reason why similar results would not be attained elsewhere.

Their findings that information is preferred to no information and that speed information is the most widely appreciated for describing conditions ahead are not surprising. In some sense, however, the preference for accident information to specific speed information under heavy traffic-flow conditions is puzzling. There appears to be an inconsistency in drivers' preferring the vague information that there is an accident ahead to the specific speed that can be anticipated. It would be reassuring to have the authors restate the specific instructions and format of this question. The motorists may possibly have interpreted the accident data as not describing the same set of operating conditions conveyed by the speed display. In fact, a number of minor inconsistencies in the quantitative data used in the study support such a request.

It would be appreciated if the authors would provide the benefit of their insight gained from this and other studies by responding to the following questions:

1. What are the relative improvements that can be expected from this type of demand redistribution in a cost-effectiveness sense as compared to other techniques available to engineers?
2. Why should voluntary choice instead of mandatory control be used in achieving this type of demand redistribution?
3. Demand redistribution is not achieved solely by conveying a message. Is it possible that the driver's decision-making process is so complex that different displays of the type used in this study may be optional under certain environmental states?

PAUL FOWLER, Automobile Club of Southern California—The American motorist clearly needs and wants more meaningful information concerning the driving task confronting him. This conclusion presented by the authors from their questionnaire sur-

vey of Illinois motorists has also been corroborated by previous surveys throughout the country concerning motorists' reactions to highway signing and radio traffic broadcasts. Although some experimentation is being done with various types of changeable-message signs, this study is especially significant because it attempts to determine what the motorist himself believes to be the most meaningful type of information. Previous research invariably attempted to measure only driver response to arbitrarily selected specific messages. The authors have identified driver preferences for visual real-time information within a broader range of alternative types of displays. Within this limited range of possibilities, the authors have tested the study results for significance and presented their conclusions in clearly understandable terms.

First in importance, the motorist wants advance information of unusual conditions such as accidents or other unpredictable disruptions ahead along his intended route. Second, he desires quantitative information in some meaningful form concerning the relative speed or travel time he may expect.

There is room for serious question that the expressed preferences for visual displays would, in fact, apply equally to audio broadcast messages as the authors assert. To be effective, visual descriptors must be concise and limited in number. On the other hand, audio messages permit greater detail, explanation, and even emphasis. Air Force research has led to adoption of pre-recorded audio messages to alert pilots to specific emergencies in preference to certain visual displays. Recent polls of radio listenership in the Los Angeles area seem to reflect significant shifts to one station that has adapted computerized techniques for broadcasting periodic estimates of travel times on specific segments of freeways during the commuter rush hours. Although these travel times are computed from historical data and are adjusted according to reported accidents or stoppages without any real-time input, the program ratings reflect the motorist's belief that travel time in minutes is meaningful information that is either helpful or reassuring to him. This indication of subjective popularity suggests that quantitative information in speed or minutes is useful, particularly if it is presented in detail or adequately explained. Certainly the possibilities inherent in audio broadcasts must be considered separately on their own merits and investigated in further research.

The authors presented to each of the motorists a visual display message in a sample photograph of a particular type of changeable-message sign rather than a simple typewritten or printed descriptor. This departure from pure research may be unfortunate in that it appears to inject the possibility of a driver bias that results from personal reactions to the particular type of sign but that might be more applicable to certain types of descriptors. Previous studies of driver response to similar changeable-message signs in the Detroit and New York areas raise some question that the readability or impact of that particular hardware could affect the stated preferences of the respondents tested. If specific limitations in the hardware could in fact affect the motorist's selections, then further studies may be necessary involving more legible messages, alternative types of hardware, or simple, printed displays.

As a final point of discussion, there is a need for further verification of driver information preferences in other metropolitan areas. For instance, the driver's needs and responses may well reflect the relative sophistication that he has attained. Conceivably this would vary throughout the country depending on the availability and complexity of the freeway network, the availability of other travel modes, and the average commuter trip-length. The motorist's needs and ability to respond in a low-density, automobile-oriented community may well be quite different from those in a high-density, geographically constrained metropolitan area.

This research effort into the subject of visual information displays is timely and represents an extremely important step in the development of improved driver information systems. It could represent the first phase of a three-phase project. The second phase would logically involve simulation tests to measure actual driver response to specific types of messages, as distinguished from this sampling of driver preferences. The final stage must necessarily involve full-scale field testing of prototype hardware, including real-time data collection systems. The need for operational improvements to obtain optimum efficiency from urban freeways, particularly during

periods of peak traffic demand, is readily apparent if we are to keep pace with shifting urban population. The authors are to be commended for their attack on this crucial problem and for their forthright presentation of the study results.

JOSEPH A. WATTLEWORTH, University of Florida, Gainesville—In this questionnaire study of the preferences of drivers for alternate visual displays, the significant findings were that (a) drivers preferred to have information about freeway traffic conditions; (b) displays presenting speed information or descriptive terms were preferred to displays presenting quantitative travel time or delay information; and (c) for heavy congestion, the drivers preferred the addition of an accident descriptor in the display.

In my view, the most significant result is that displays that present speed information or descriptive terms were preferable to displays that present quantitative travel time or delay information. This would indicate that motorists do not evaluate alternate routes in terms of travel time and delay, but rather that they tend to think in terms of speed or some other reference parameter—perhaps comfort and convenience. This is not necessarily to say that the motorists do not end up taking the minimum-travel-time route, but merely that they do not evaluate the alternate specifically in terms of travel time. Because most traffic assignment procedures are based on some minimum-travel-time principle, this point is quite significant and suggests that further investigation into the philosophy of traffic assignment is warranted.

This research finding is significant for another reason. For years many traffic experts have argued that drivers do, indeed, think in terms of minimum travel time when they are selecting from alternate routes. These experts have based many decisions on this premise. Research has shown that, in this case, expert professional opinion was wrong and one must wonder how many more similar examples one could find. Too many standards, policies, and guidelines are established by committee consensus or by a similar edict by knowledgeable people who are forced to act without thorough factual documentation of the wisdom of their course of action. Too often, then, these standards, policies, and guidelines are never questioned because of the professional esteem of the originators. These comments are intended not to question the professional abilities of anyone but to emphasize the value of research in providing more factual information on which to base or check traffic engineering decisions. Specifically, it is suggested that further research of this type be conducted to evaluate driver preferences for information in other signing situations.

Good research, in addition to answering the initial question or questions, should serve to raise other questions for further investigation, and this research has done this. Many of these questions are related to the systems aspects rather than to merely the display aspects of a freeway driver information system and are concerned with system operation, system performance, and driver reaction, all of which are beyond the scope of the present investigation. Several of these questions are discussed in the following paragraphs.

Will a significant number of drivers who are told of heavy freeway congestion actually divert to alternate routes? Numerous studies in Houston (9) and elsewhere have indicated that many motorists actually increase their trip time and distance in order to use freeways for parts of their trips. If the freeway is this attractive to the motorists, they may be reluctant to divert from it.

Is it sufficient to present information only regarding freeway conditions, or must information also be presented on alternate route conditions? The descriptions of the Freeway Driver Information System in the paper suggested that only freeway information would be presented. This still leaves the driver in somewhat of a quandary regarding conditions on the alternate route unless the operation of the alternate route is unusually consistent and insensitive to changes in demand caused by the diversion. The driver is interested, it would appear, in information on which he can base a selection of an alternate route, and merely having knowledge of freeway conditions may not be

adequate in most instances. If an attempt is made to provide information on the best alternate route to a point, system stability must be considered. In many freeway corridors in which the demand is fairly close to capacity, shifts in some demand may cause congestion on the best route, thereby ending its status as best route. The information system may then oscillate between the alternate routes in designating them as best routes.

Should the accident descriptor be used to emphasize the heavy-congestion message only when there actually is an accident? It would appear that indicating an accident when there is none would adversely affect the drivers' confidence in the system. The use of the accident descriptor should probably be questioned from another point of view. Although the drivers indicated a preference for this additional information, it is not clear how it would be used. Specifically, it is not clear whether this additional information would encourage diversion from the freeway or whether it would tend to encourage drivers to use the freeway to be able to see the accident.

In summary, the paper was quite good and presented some very important findings regarding the display portion of the Freeway Driver Information System. Several other questions relating to system operation, system performance, and driver reactions to such a system have been left for subsequent investigations.

Reference

9. McCasland, W. R. Traffic Characteristics of the Westbound Freeway Interchange Traffic of the Gulf Freeway. Texas Transportation Institute, Texas A&M Univ., College Station, Research Rept. 24-7, 1964.

KENNETH W. HEATHINGTON, RICHARD D. WORRALL, and GERALD C. HOFF, Closure—The authors wish to express their appreciation to the 3 discussers for the manner in which they conducted their reviews. Basically, we believe all of the questions raised are very pertinent to the research at hand. Some of these questions, perhaps, we can answer. Others are simply not covered in our research. Because this presentation represents only a small part of the overall project performed at the Expressway Surveillance Project, it does not address some of the questions that have come forth. These would tend to be explained by an exploration of other parts of the research. In a brief manner, however, we will attempt to make some comments that should help in clarifying some of the points raised.

Our statement that the results of this research might be applicable to audio systems was to imply that the information areas of interest should be compatible. That is, if information on speed is highly preferred in a visual display, perhaps this same type of information would be highly preferred in an audio broadcast. Furthermore, we do not feel that the signs biased the answers of the respondents in any manner. The method of paired comparisons forced the respondent to choose between 2 signs that differed only by their messages. Thus the respondent really had a choice only between messages.

We believe (and this is based partly on conversations with a few of the respondents) that drivers in the Chicago area are deeply concerned about being caught in a traffic tie-up caused by an accident. The accident descriptor probably conveys to the respondents a mixture of conditions such as inconvenience, discomfort, slow speeds, stalled traffic, and long delays. All of these, of course, the driver would like to avoid. Although each respondent was specifically instructed that the paired signs were intended to convey exactly the same conditions (with the exception of a blank sign), it is possible that some respondents may have mentally interpreted them differently.

The relative improvements that can be expected from a demand redistribution have not been evaluated in a cost-effectiveness framework. Preliminary examination, however, indicates that the cost of information systems may be substantially less than that of other techniques appropriate for redistributing the demand. The important point to

recognize is the ability of a particular information system to significantly influence the redistribution of demand. We believe that an information system can be effective but, of course, our research has not progressed sufficiently to substantiate this belief. We certainly subscribe to a voluntary rather than a forced redistribution of demand for the more obvious reasons of cost, capabilities, practicallity, and user acceptance. One can, of course, present further arguments for a voluntary redistribution of demand.

We would prefer a very elaborate information system operating in real time. Conceptually, this information system should cover all modes and all facilities so that conditions are known with some degree of certainty at any time a query is made. We realize, however, that it is difficult to begin with such an elaborate system. For this reason, the overall research was directed toward a system that is within our present capabilities of resources and technology.