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Driver Attitudes Concerning Aspects of Highway Navigation

GERHART F. KING

A comprehensive questionnaire dealing with various aspects of highway navigation was developed, pretested, and administered to a demographically representative sample of the U. S. driving population. The sample was drawn from a group of paid subjects engaged in highway navigation experiments. The analysis of 125 completed and usable questionnaires is presented. In addition to background information on demographics and on driving experience, topics addressed included route selection, behavior under directional uncertainty, distance-time-costs trade-offs, and attitudes toward proposed remedial measures. The data obtained indicate that drivers are, generally, fairly well satisfied with their ability to perform route-planning or route-following tasks effectively and believe that the major constraints on their effectiveness arise from the unavailability of adequate and accurate route and traffic information. This satisfaction is, however, not supported by data on the extent of excess travel due to navigational waste. Furthermore, answers to a number of questions indicated an insufficient appreciation of the complexities of determining optimum routes and of the extent and seriousness of the problem of navigational waste.

The purpose of all motor vehicle travel, except for the extremely small proportion classified as pleasure driving, is to proceed from an origin to a destination. The aggregate of all such travel represents the total miles driven in the United States—an aggregate total that approached 1.8 trillion miles in 1985 (*1*).

All driving accrues costs that are incurred by the vehicle operator or owner, or both; by other vehicle occupants; by public agencies responsible for the construction, maintenance, and operation of the highway system; by owners of property abutting the travel route; and by society as a whole.

With increasing constraints on the availability of resources, increasing awareness of the importance of environmental conservation, and increasing awareness of the enormous societal costs of highway accidents, it has become imperative to reduce these costs to the maximum extent possible. One approach to achieving this objective is to minimize total travel without a change in the aggregate origin-destination matrix by implementing measures that will increase the probability that all trips will be made on optimum routes. This approach is designed to minimize or eliminate unproductive or excess travel. Excessive travel implies a failure in route selection or route following, or both.

A survey of existing literature on the subject (*2*) indicated that efficiency of route selection and route following may be affected by such driver demographic attributes as age, sex,

KLD Associates, Inc., 300 Broadway, Huntington Station, N.Y. 11746.

TABLE 1 SUBJECTS BY AGE

Age (years)	Connecticut			Wisconsin			All		
	Male	Female	All	Male	Female	All	Male	Female	All
18	1	0	1	3	0	3	4	0	4
19	1	0	1	1	1	2	2	1	3
20	0	0	0	1	1	2	1	1	2
21	2	1	3	3	1	4	5	2	7
22	1	1	2	0	0	0	1	1	2
23	1	0	1	0	1	1	1	1	2
24	0	0	0	2	2	4	2	2	4
25	0	0	0	2	0	2	2	0	2
26	0	1	1	2	1	3	2	2	4
27	0	0	0	1	2	3	1	2	3
28	1	1	2	1	1	2	2	2	4
29	1	0	1	0	0	0	1	0	1
30	0	2	2	0	1	1	0	3	3
31	2	0	2	2	0	2	4	0	4
32	0	0	0	4	0	4	4	0	4
33	1	0	1	1	2	3	2	2	4
34	0	0	0	3	0	3	3	0	3
35	2	1	3	0	0	0	2	1	3
36	0	0	0	2	0	2	2	0	2
37	1	0	1	2	1	3	3	1	4
39	0	0	0	0	1	1	0	1	1
40	0	1	1	2	1	3	2	2	4
41	1	0	1	2	0	2	3	0	3
42	4	1	5	0	1	1	4	2	6
43	0	0	0	0	2	2	0	2	2
44	1	0	1	1	2	3	2	2	4
45	2	0	2	2	0	2	4	0	4
46	1	0	1	0	0	0	1	0	1
47	0	0	0	3	1	4	3	1	4
48	0	1	1	0	1	1	0	2	2
49	0	1	1	1	0	1	1	1	2
50	0	0	0	2	1	3	2	1	3
51	0	1	1	1	0	1	1	1	2
52	1	0	1	0	0	0	1	0	1
53	0	0	0	0	1	1	0	1	1
54	1	1	2	0	0	0	1	1	2
55	2	0	2	2	0	2	4	0	4
56	1	1	2	1	0	1	2	1	3
57	0	0	0	2	0	2	2	0	2
58	0	0	0	1	1	2	1	1	2
59	0	0	0	1	0	1	1	0	1
62	0	0	0	2	0	2	2	0	2
68	1	0	1	0	0	0	1	0	1
73	1	0	1	0	0	0	1	0	1
Mean	39.5	38.0	39.0	37.5	35.5	36.9	38.3	36.4	37.6
N	30	14	44	53	26	79	83	40	123
No answer	0	0	0	2	0	2	2	0	2

education, and driving experience. The degree of trip optimization may also be affected by driver attitudes, beliefs, and behavior patterns such as selection of route choice criteria, perceived driving costs, and distance-time trade-off patterns. A comprehensive questionnaire was therefore designed to solicit information on these subjects. The questionnaire covered the following topics:

- Demographic attributes,
- Driving experience,
- Perceived driving costs and time-distance trade-offs,
- Trip-planning behavior and skills, and
- Evaluation of candidate remedial measures.

The questionnaire was administered to all participants in a series of empirical experiments on route planning and route following reported elsewhere (*3*). Data were collected in Connecticut and Wisconsin and a total of 125 usable replies were received. This total represents 93 percent of all participants in the experiments.

DEMOGRAPHIC DATA

Subjects were recruited through newspaper advertisements, word of mouth, and previously established contacts. The subjects, who were paid, had to meet the following requirements:

- Valid driving license unrestricted except for eyeglasses and
- No current, or previous, professional activities that involved driving, route planning, or any aspect of highway or traffic engineering.

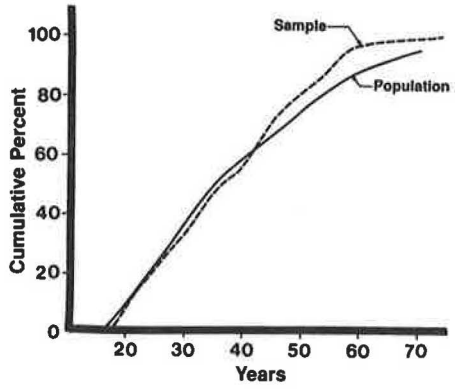

FIGURE 1 Subjects by age.

Table 1 gives the distribution of respondents by sex, age, and location of the experiment. Figure 1 shows a comparison of this distribution and the age distribution of the U. S. adult population weighted by actual miles driven. On a nationwide basis (*4*) women drive 37.4 percent of all non-work-related vehicle miles traveled (VMT); 32.0 percent of all subjects were female. Figure 2 shows the distribution of respondents by education as well as comparable data for the U. S. population.

These data show that the sample was somewhat nonrepresentative of older drivers (i.e., the approximately 5 percent of total VMT accumulated by drivers over 70). This difference is not statistically significant.

Sample subjects were better educated than the population as a whole (*5*), and Connecticut subjects were better educated than those in Wisconsin, which reflects the overall difference in education in these two states:

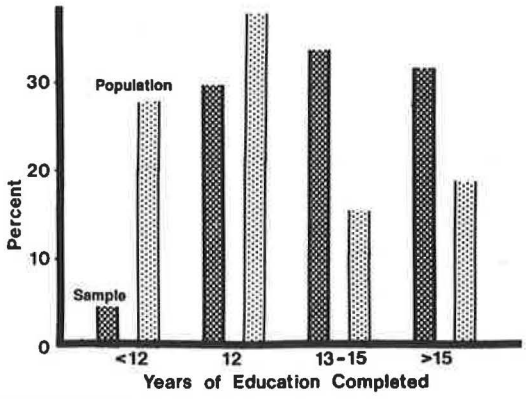

FIGURE 2 Subjects by education.

	High School Graduates (%)	*College Graduates (%)*
Connecticut		
Sample	93.8	61.4
Population	70.3	20.7
Wisconsin		
Sample	97.7	15.0
Population	69.6	14.8
U. S. population	66.5	16.2

That the subjects were better educated than the population as a whole does not detract from the results because past studies (*6*) have indicated that both the number and the length of long trips, especially to unfamiliar areas, are positively correlated with education.

DRIVING EXPERIENCE

Table 2 gives self-reported estimates of annual travel by major trip purpose classification and by degree of familiarity with the

TABLE 2 AVERAGE ANNUAL VMT BY TRIP PURPOSE

	Male	Female	Total
Work or Business Related			
Mean (mi)	8,623	3,857	7,070
Standard deviation (mi)	7,500	3,980	6,913
Percentage of total	51.9	27.2	44.9
Percentage familiar	82.6	82.1	82.5
Family or Personal Business			
Mean (mi)	3,441	4,090	3,634
Standard deviation (mi)	2,399	3,548	2,777
Percentage of total	20.7	28.8	23.0
Percentage familiar	74.3	82.4	77.0
Civic, Educational, Religious			
Mean (mi)	1,046	1,820	1,327
Standard deviation (mi)	1,014	2,408	1,682
Percentage of total	6.3	12.8	8.4
Percentage familiar	76.3	82.9	79.6
Social and Recreational			
Mean (mi)	3,698	2,587	3,333
Standard deviation (mi)	2,838	1,876	2,602
Percentage of total	22.3	18.2	21.1
Percentage familiar	58.7	59.5	58.9
All Purposes			
Mean (mi)	16,616	14,177	15,782
Standard deviation (mi)	8,242	8,380	8,259
Percentage familiar	72.1	73.5	72.5

TABLE 3 ESTIMATED DRIVING COST PER MILE

	Connecticut			Wisconsin			All		
	Male	Female	All	Male	Female	All	Male	Female	All
Freeways									
Mean	14.9	22.2	16.9	19.1	33.9	23.5	17.6	30.1	21.2
SD	8.2	30.1	17.1	21.4	40.4	29.0	17.9	37.3	25.7
No.	29	11	40	53	23	76	82	34	116
Rural Roads									
Mean	16.6	24.4	18.6	21.0	41.4	27.4	19.3	36.1	24.2
SD	9.0	37.0	19.9	24.0	47.9	34.4	19.7	44.9	30.2
No.	29	10	39	48	22	70	77	32	109
Normal City Driving									
Mean	19.2	28.3	21.6	26.5	44.7	32.2	24.0	39.9	28.7
SD	10.1	44.5	23.9	33.6	55.6	42.2	28.0	52.5	37.4
No.	28	10	38	53	24	77	81	34	115
Congested City Driving									
Mean	23.3	41.9	28.2	33.0	56.7	40.3	29.6	52.2	36.2
SD	13.0	74.8	39.4	40.0	69.5	51.6	33.3	70.3	48.0
No.	28	10	38	52	23	75	80	33	113

Note: Entries are in cents. SD = standard deviation.

route and the area. It should be noted that these VMT estimates are considerably higher than commonly accepted values derived from trip diaries or motor fuel sales. The distribution of VMT by trip purpose, however, roughly parallels similar figures abstracted from National Personal Transportation Survey (NPTS) data (*3*) if allowances are made for the fact that persons who drove as part of their employment were systematically excluded from the sample. It is worthy of note that, in the present context, 27.5 percent of all travel represents nonfamiliar trips.

PERCEIVED DRIVING COSTS

The subjects were asked to estimate the actual cost of driving under four different driving conditions. A summary of responses is given in Table 3. Examination of this table reveals a number of interesting points:

- The mean of the estimated costs was of the correct order of magnitude and fell between previously reported figures (*7*, *8*) for out-of-pocket (variable) and total costs.
- Subjects, as a whole, were accurate in rank ordering estimated driving costs for different driving conditions.
- Estimates made by female subjects were generally significantly higher than those made by male subjects. Responses by female subjects also showed much higher variability.

Table 4 gives a summary of the answers to a question dealing with distance-time trade-offs. Examination of these data shows fairly consistent results for all three variables: sex of subject, experiment location, and trip purpose. It is interesting to note that less than one-quarter of all respondents were willing to make any trade-offs for savings of 1 min. This proportion increases rapidly as the time savings becomes larger (Figure 3).

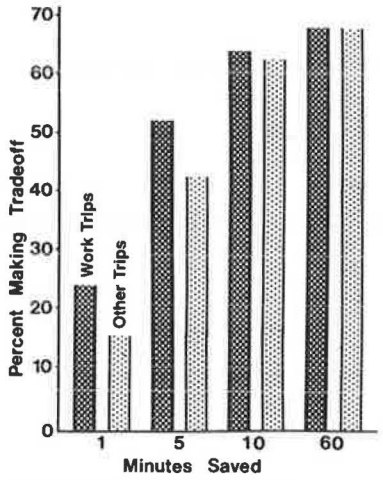

FIGURE 3 Proportion of respondents willing to make trade-off.

In Table 5 these distance-time trade-offs are converted to a cost-time trade-off. The table was constructed by multiplying, for each subject, the "extra" miles by the estimated cost of driving 1 mi (using the mean of the four driving conditions). These computations indicate an imputed mean value of time of approximately $7.30 per hour as detailed in the following table:

	Imputed Value of Time ($)	
	Work Trips	*Other Trips*
Connecticut		
Male	5.13	4.99
Female	11.42	12.54
All	6.51	6.64
Wisconsin		
Male	7.42	5.28
Female	14.42	10.22
All	9.62	6.46
All		
Male	6.47	5.16
Female	13.51	11.07
All	8.42	6.53

The differences between the value of time assigned to "work" and to "other" are not statistically significant. Similarly, there were no significant differences attributable to either sex of subject or location. The value of the coefficient of variation approached or exceeded 1.0 in every instance.

TRIP-PLANNING BEHAVIOR AND SKILLS

All subjects were asked to rate themselves on a seven-point semantic scale (ranging from very poor to very good) with respect to five important trip-planning and route-following skills. The responses to these questions are summarized in

TABLE 4 DISTANCE-TIME TRADE-OFFS

	Connecticut			Wisconsin			All		
	Male	Female	All	Male	Female	All	Male	Female	All
Extra Miles to Save 1 min: Work Trips									
Mean	1.6	1.7	1.6	1.2	1.0	1.2	1.4	1.3	1.3
SD	0.9	0.6	0.8	0.4	0.	0.4	0.7	0.5	0.6
No.	9	3	12	13	5	18	22	8	30
Extra Miles to Save 1 min: Other Trips									
Mean	1.4	2.5	1.7	1.1	1.0	1.1	1.3	2.0	1.4
SD	0.8	0.7	0.9	0.3	0.	0.3	0.6	1.0	0.7
No.	7	2	9	9	1	10	16	3	19
Extra Miles to Save 5 min: Work Trips									
Mean	3.0	3.2	3.0	3.5	3.2	3.4	3.3	3.2	3.2
SD	1.7	2.7	1.9	2.3	1.9	2.1	2.0	2.1	2.0
No.	21	5	26	27	12	39	48	17	65
Extra Miles to Save 5 min: Other Trips									
Mean	3.1	3.5	3.2	4.0	3.4	3.8	3.6	3.4	3.5
SD	1.8	3.5	2.3	2.6	3.1	2.7	2.3	3.2	2.5
No.	17	6	23	22	8	30	39	14	53
Extra Miles to Save 10 min: Work Trips									
Mean	5.7	6.3	5.8	6.2	6.4	6.2	6.0	6.4	6.1
SD	3.1	4.7	3.4	5.2	4.1	4.8	4.4	4.2	4.3
No.	24	7	31	34	15	49	58	22	80
Extra Miles to Save 10 min: Other Trips									
Mean	6.7	7.5	6.9	6.9	7.2	7.0	6.8	7.3	6.9
SD	4.5	5.7	4.7	5.4	6.5	5.7	5.0	6.1	5.3
No.	24	8	32	33	13	46	57	21	78
Extra Miles to Save 1 hr: Work Trips									
Mean	27.9	17.5	25.4	24.5	24.1	24.4	26.0	21.9	24.8
SD	18.6	12.0	17.7	16.7	17.7	16.8	17.5	16.1	17.1
No.	26	8	34	35	16	51	61	24	85
Extra Miles to Save 1 hr: Other Trips									
Mean	27.4	17.2	24.8	25.2	20.0	23.9	26.1	18.8	24.3
SD	18.2	13.0	17.4	16.7	11.7	15.7	17.2	12.0	16.3
No.	26	9	35	38	12	50	64	21	85

Note: SD = standard deviation.

TABLE 5 COST-TIME TRADE-OFFS

	Connecticut			Wisconsin			All		
	Male	Female	All	Male	Female	All	Male	Female	All
Extra Cost to Save 1 min: Work Trips									
Mean	21.7	118.3	45.8	37.4	46.0	39.8	31.0	73.1	42.2
SD	12.8	167.9	84.6	82.2	44.0	72.4	63.1	102.8	76.1
No.	9	3	12	13	5	18	22	8	30
Extra Cost to Save 1 min: Other Trips									
Mean	20.6	249.0	71.3	15.1	37.0	17.3	17.5	178.3	42.9
SD	10.0	309.7	149.1	10.0	0.	11.7	10.5	250.9	103.5
No.	7	2	9	9	1	10	16	3	19
Extra Cost to Save 5 min: Work Trips									
Mean	49.0	241.6	87.5	72.2	190.4	109.6	62.1	205.5	100.8
SD	41.8	476.2	213.0	81.8	269.7	171.0	67.8	327.5	187.4
No.	20	5	25	26	12	38	46	17	63
Extra Cost to Save 5 min: Other Trips									
Mean	53.8	334.6	120.7	112.0	273.1	156.4	86.8	296.8	141.4
SD	44.8	685.6	332.4	264.6	598.9	380.9	201.4	605.7	358.2
No.	16	5	21	21	8	29	37	13	50
Extra Cost to Save 10 min: Work Trips									
Mean	101.4	425.0	168.3	119.5	403.5	208.3	112.1	409.7	193.2
SD	81.4	938.5	424.6	121.7	682.9	408.3	106.5	739.4	412.2
No.	23	6	29	33	15	48	56	21	77
Extra Cost to Save 10 min: Other Trips									
Mean	115.4	511.3	197.3	143.4	464.8	236.2	131.7	479.5	221.0
SD	101.6	1125.4	510.8	231.1	1183.9	664.5	187.2	1134.3	605.5
No.	23	6	29	32	13	45	55	19	74
Extra Cost to Save 1 hr: Work Trips									
Mean	513.4	1142.1	650.9	742.4	1442.2	961.9	647.0	1350.9	842.0
SD	452.4	2594.6	1237.4	1432.1	2824.7	1973.8	1130.5	2701.1	1725.6
No.	25	7	32	35	16	51	60	23	83
Extra Cost to Save 1 hr: Other Trips									
Mean	498.6	1253.6	663.8	527.7	1021.7	646.3	516.2	1107.1	653.1
SD	453.5	2889.1	1369.4	727.0	1951.2	1139.8	628.6	2263.2	1226.3
No.	25	7	32	38	12	50	63	19	82

Note: SD = standard deviation.

Table 6. Both the numerical mean rating (very good = 7, very poor = 1) and the modal verbal rating are given.

It can be seen that, in general, Connecticut subjects rate themselves higher than Wisconsin subjects and male subjects higher than female subjects. The geographic differences may be due to a higher educational level for the Connecticut subjects or it may reflect the belief that a higher level of route-planning and route-following skills is required, and therefore developed, in the eastern part of the country because of the generally more complex road network. A lower skill level may be considered adequate for navigating the predominantly Cartesian grid networks of the Midwest. The sex-based difference appears to reflect population stereotypes. It should be noted that only very minor sex-based differences were found in the empirical portions of the research program (see paper by King in this Record).

In general, the subjects had a fairly high opinion of their route-planning and route-following skills. Although the modal response was "average" (31 percent of all individual responses), responses of good or very good were more than 12 times more prevalent than responses of poor or very poor.

The responses to a question concerning the most likely

TABLE 6 ABILITY SELF-RATING

Subject Group	Reading Maps			Planning Routes		Obtaining Materials for Trip Planning		Following Self-Planned Routing		Following Routes Planned by Others	
	N	Mean	Mode[a]	Mean	Mode[a]	Mean	Mode	Mean	Mode	Mean	Mode
Connecticut											
Male	30	5.73	VG	5.53	GD	5.27	AA	5.43	AV	5.28	GD
Female	14	4.79	GD	4.21	AV/BA	5.43	GD	5.36	GD	5.14	GD
All	44	5.43	VG	5.11	GD	5.32	GD	5.41	AV	5.23	GD
Wisconsin											
Male	55	5.07	GD	5.13	GD	5.20	GD	5.29	AV	4.93	AV
Female	26	3.88	AV/BA	4.23	AV	4.88	AV	4.81	AV	5.27	AV
All	81	4.69	AV	4.84	AV	5.10	AV	5.14	AV	5.04	AV
All											
Male	85	5.31	GD	5.27	GD	5.22	GD	5.34	AV	5.05	AV
Female	40	4.20	AV/BA	4.22	AV	5.07	AV	5.00	AV	5.22	AV
All	125	4.95	AV	4.94	GD	5.18	AV	5.23	AV	5.10	AV

Note: VG = very good, GD = good, AA = above average, AV = average, and BA = below average.
[a]Two entries indicate a bimodal distribution.

action to be taken in the face of directional uncertainty are summarized in Table 7. Subjects were given three different types of action and asked to estimate the frequency with which they would adopt each of these. The responses show that male subjects are more likely to resort to maps and that female subjects are more likely to ask for directions.

Because the probability of identifying the optimum route is a function of the number of alternate routes tried, the subjects were asked how many routes were tried before the route normally taken for frequent trips was selected. The responses are summarized in Table 8 and shown graphically in Figure 4. It can be seen that the responses were fairly consistent across all subject groups. Most subjects tried two or three alternate routes and evaluation of four or more routes was infrequent. Connecticut drivers generally tried more alternate routes than Wisconsin drivers, which possibly reflects differences in the extent and complexity of the road systems in the two test areas.

EVALUATION OF CANDIDATE REMEDIAL MEASURES

The subjects were presented with a list of 17 remedial measures that had been previously advocated (*2*). These measures were

A—Teach map-reading skills in driver education classes,
B—Teach map-reading skills in adult education classes,
C—Teach map-reading skills in TV courses,
D—Teach comprehensive trip-planning skills in driver education classes,
E—Teach comprehensive trip-planning skills in adult education classes,
F—Teach comprehensive trip-planning skills in TV courses,
G—Make maps easier to read,
H—Make maps more available,
I—Improve directional and informational signing on freeways and expressways,
J—Improve directional and informational signing on city streets,
K—Improve directional and informational signing on rural highways,
L—Make trip-planning help available by telephone,
M—Make trip-planning help available by home computer,
N—Make traffic conditions and detour information available by telephone,
O—Improve accuracy and frequency of radio traffic reports,
P—Provide automotive in-vehicle systems that determine and show vehicle location, and
Q—Provide automatic in-vehicle systems that determine and show the best route.

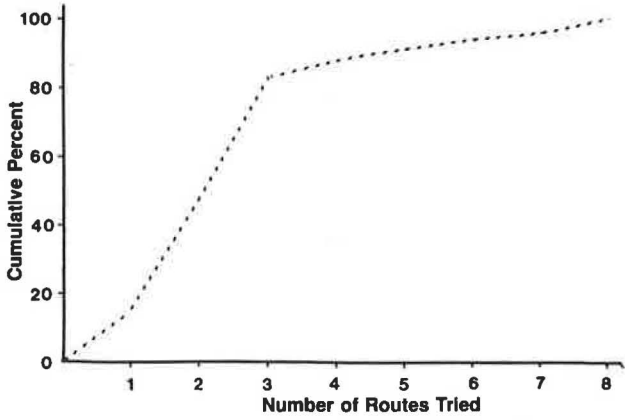

FIGURE 4 Cumulative distribution of alternative routes tried.

TABLE 7 ACTION WHEN LOST

	Never	Rarely or Sometimes	Usually or Frequently
Stop and Try To Figure Things Out with a Map			
Connecticut			
Male	0.0	23.3	76.7
Female	14.3	28.6	57.2
All	4.5	22.7	70.4
Wisconsin			
Male	1.8	30.9	67.3
Female	11.5	30.8	57.7
All	4.9	30.9	64.2
All			
Male	1.2	70.6	70.6
Female	12.5	60.0	57.5
All	4.8	67.2	66.4
Try To Find a Gas Station Attendant or Some Other Person To Ask			
Connecticut			
Male	0.0	60.0	40.0
Female	0.0	7.1	92.9
All	0.0	43.2	56.8
Wisconsin			
Male	0.0	38.2	61.8
Female	0.0	34.6	65.4
All	0.0	37.0	54.1
All			
Male	0.0	45.9	54.1
Female	0.0	25.0	75.0
All	0.0	39.2	60.8
Keep Driving Until Bearings Are Reestablished			
Connecticut			
Male	0.0	86.7	13.3
Female	14.3	71.4	14.3
All	4.5	81.9	13.6
Wisconsin			
Male	9.1	80.0	10.9
Female	11.5	69.2	19.2
All	9.9	76.6	13.5
All			
Male	12.5	70.0	17.5
Female	12.5	70.0	17.5
All	8.0	78.4	13.6

Note: Entries are percentage of respondents.

The subjects were asked to rate each of these items on a six-point scale ranging from "not at all important" to "very important." Results for all subjects are given in Table 9. The mean ratings for individual subgroups of subjects are given in Table 10. The 17 items were ranked on the basis of the mean ratings. The Spearman rank correlation test showed extremely high uniformity:

Comparison	*Rank Correlation*
Male versus female	
Connecticut	0.97
Wisconsin	0.91
All	0.97
Connecticut versus Wisconsin	
Male	0.93
Female	0.92
All	0.93

The 17 items fall into seven natural classes. The rank ordering of these classes is as follows:

1. Signing improvements (Items I, J, and K);
2. Map contents and availability (Items G and H);
3. Real-time traffic condition information (Items N and O);
4. Map-reading skills (Items A, B, and C);
5. Trip-planning skills (Items D, E, and F);
6. Trip-planning help (Items L and M); and
7. Navigation and guidance systems (Items P and Q).

Only the first two of these classes received mean importance ratings of "important" or better. Closer examination of these data shows that

- Improvements in signing, in map availability and accuracy, and in real-time traffic information (i.e., the items most often used for individual route following and trip planning) dominate the ratings.
- Improving skills is less important than improving performance aids. The preferred setting for skill improvements is driver education, which implies that this improvement is needed by others and not by the subjects who were all licensed

TABLE 8 NUMBER OF ROUTES TRIED

	No.	Mean	Standard Deviation	Median	Mode	85th Percentile
Connecticut						
Male	29	3.21	1.95	2	3	5
Female	14	3.36	2.41	2	2	7
All	43	3.26	2.08	3	2.3[a]	6
Wisconsin						
Male	53	2.64	1.36	2	3	3
Female	26	2.77	1.53	3	3	4
All	79	2.68	1.41	3	3	3
All						
Male	82	2.84	1.61	3	3	4
Female	40	2.97	1.87	2.5	2	4
All	122	2.89	1.69	3	3	4

[a]Bimodal.

TABLE 9 RELATIVE IMPORTANCE OF RATINGS–ALL SUBJECTS

Item	Not at All Important	Not Important	Probably Not Important	Possibly Important	Important	Very Important	Rank	Mean Rating	Standard Deviation	Coefficient of Variation
A		4.2	6.7	15.0	45.0	29.2	6	4.88	1.04	0.21
B	3.3	7.4	9.8	27.9	39.3	12.3	10	4.30	1.22	0.28
C	9.0	17.2	18.0	30.3	19.7	5.7	17	3.52	1.37	0.39
D	4.1	3.3	9.9	24.8	34.7	23.1	9	4.52	1.27	0.28
E	4.2	4.2	12.6	32.8	33.6	12.6	11	4.25	1.21	0.28
F	10.0	14.2	17.5	32.5	19.2	6.7	16	3.57	1.39	0.39
G	0.8	3.3	5.8	14.1	31.4	44.6	4	5.06	1.12	0.22
H	1.6	2.5	4.9	13.9	35.3	41.8	5	5.04	1.12	0.22
I	2.5	3.3	3.3	7.4	27.3	56.2	3	5.22	1.19	0.23
J	0.8	1.6	3.3	6.6	32.0	55.7	2	5.34	0.96	0.18
K	0.8	1.6	4.1	6.6	25.4	61.5	1	5.39	0.99	0.18
L	5.0	9.9	12.4	40.5	21.5	10.7	12	3.96	1.27	0.32
M	7.5	10.0	20.0	42.5	15.0	5.0	15	3.63	1.22	0.34
N	0.8	4.1	7.4	31.2	34.4	22.1	8	4.61	1.09	0.24
O	2.1	2.1	6.3	24.0	41.7	24.0	7	4.73	1.09	0.23
P	9.1	18.2	14.9	24.8	19.8	13.2	14	3.68	1.53	0.42
Q	13.1	13.9	8.2	29.5	24.6	10.7	13	3.70	1.56	0.42

Note: Table entries for columns 2–7 are percentages.

drivers. This attitude is consistent with the optimistic self-rating in Table 6.

- Assistance in, or delegation of, the trip-planning and route-following tasks is ranked rather low, which implies, again, that subjects consider themselves perfectly capable of handling these tasks if they have adequate information. The low rating of navigation and guidance systems may also be partly due to the relative unfamiliarity of the concepts involved. This unfamiliarity is also the probable reason that these two items show the highest value for the coefficient of variation.

The final topic addressed by the questionnaire concerned the perceived value, as expressed by willingness to pay, of a number of different remedial measures. The question concentrated on the more innovative measures, that is, on those that generally are not currently available. A summary of responses is given in Table 11. The table gives means and standard deviation for all respondents who gave a nonzero response as well as the percentage of all respondents who gave such a response. The data presented can be compared with the following information.

- Individual American Automobile Association membership—Connecticut $65.00 per year and Wisconsin $35.00 per year.
- The only in-vehicle navigation and guidance system commercially available in the United States is the ETAK navigator, a self-contained vehicle location and map display system. The system is designed to sell for approximately $1,500. Assuming

TABLE 10 RELATIVE IMPORTANCE RATINGS, SUMMARY

	Connecticut			Wisconsin			All		
Item	Male	Female	All	Male	Female	All	Male	Female	All
A	4.83	5.21	4.95	4.65	5.24	4.84	4.72	5.23	4.88
B	4.03	4.36	4.14	4.21	4.76	4.38	4.14	4.62	4.30
C	3.17	3.79	3.36	3.51	3.80	3.60	3.39	3.79	3.52
D	4.50	5.00	4.66	4.23	4.88	4.44	4.33	4.92	4.52
E	3.90	4.54	4.10	4.25	4.52	4.34	4.12	4.53	4.25
F	3.03	3.92	3.31	3.51	4.12	3.71	3.34	4.05	3.57
G	4.79	5.57	5.05	4.83	5.56	5.06	4.82	5.56	5.06
H	5.00	5.21	5.07	4.89	5.32	5.03	4.93	5.28	5.04
I	5.60	5.64	5.61	4.65	5.72	5.00	5.00	5.69	5.22
J	5.63	5.79	5.68	4.91	5.68	5.15	5.17	5.72	5.34
K	5.67	5.86	5.73	4.96	5.68	5.19	5.22	5.74	5.39
L	3.77	3.93	3.82	3.81	4.54	4.04	3.80	4.32	3.96
M	3.79	4.14	3.91	3.51	3.38	3.47	3.61	3.66	3.63
N	4.30	4.57	4.39	4.49	5.24	4.73	4.42	5.00	4.61
O	4.68	5.29	4.88	4.38	5.12	4.61	4.51	5.19	4.73
P	3.63	3.86	3.70	3.40	4.20	3.66	3.49	4.08	3.68
Q	3.70	4.07	3.82	3.30	4.36	3.64	3.45	4.26	3.70

TABLE 11 WILLINGNESS TO PAY FOR IMPROVEMENTS ($)

	Connecticut			Wisconsin			All		
	Male	Female	All	Male	Female	All	Male	Female	All
AAA Type of Trip-Planning Service									
Mean	28.19	30.63	28.86	16.03	24.75	19.13	21.14	26.71	22.95
SD	15.98	12.66	14.95	10.79	16.70	13.67	14.40	15.45	14.88
No.	21	8	29	29	16	45	50	24	74
Percentage	70.00	57.14	65.91	55.77	72.73	60.81	60.98	66.67	62.71
Trip-Planning Packages for a Home Computer									
Mean	26.50	56.88	35.85	15.79	27.50	20.88	22.01	40.56	28.82
SD	23.74	40.70	32.43	9.06	29.18	20.69	19.52	36.86	28.30
No.	18	8	26	13	10	23	31	18	49
Percentage	66.67	61.54	65.00	28.26	47.62	34.33	42.47	52.94	45.79
In-Vehicle Systems That Show the Exact Location of the Car									
Mean	124.33	34.00	101.75	107.50	60.00	88.20	114.93	52.78	93.41
SD	244.56	17.10	213.87	228.45	67.21	180.59	232.19	58.32	192.12
No.	15	5	20	19	13	32	34	18	52
Percentage	53.57	38.46	48.78	37.25	56.52	43.24	43.04	50.00	45.22
In-Vehicle Systems That Show Both Location and Route to Destination									
Mean	141.25	50.00	116.36	126.02	57.50	99.37	132.43	55.25	105.82
SD	233.35	24.29	201.90	220.29	66.90	178.68	222.88	56.83	186.26
No.	16	6	22	22	14	36	38	20	58
Percentage	55.17	46.15	52.38	43.14	60.87	48.65	47.50	55.56	50.00
In-Vehicle Systems That Show Location and Best Route to Destination Given Current Traffic and Weather Conditions									
Mean	145.00	106.25	134.67	160.00	48.82	117.04	153.26	67.20	124.19
SD	219.86	97.39	193.89	283.45	61.33	230.17	254.41	77.60	214.98
No.	22	8	30	27	17	44	49	25	74
Percentage	73.33	61.54	69.77	55.10	70.83	60.27	62.03	67.57	63.79
In-Vehicle Systems That Tell Exactly How To Go at Each Choice Point									
Mean	161.76	115.13	146.84	89.78	65.38	79.55	124.74	84.33	109.59
SD	246.93	134.02	215.36	126.78	67.22	105.19	195.10	98.03	165.57
No.	17	8	25	18	13	31	35	21	56
Percentage	58.62	61.54	59.52	36.00	56.52	42.47	44.30	58.33	48.70

a median vehicle lifetime of 12 years (*6*), an interest rate of 10 percent, and no scrap value, the equivalent annual cost is $220 to which must be added about $30 a year for new and updated digital map cassettes.

- A trip-planning package for home computers can be assumed to cost about $200 for the basic software and about $30 per year for map cassettes. If the economic life is assumed to be 5 years, the equivalent total annual cost is about $83.

Examination of the data collected shows that the subjects' willingness to pay was considerably less than the anticipated probable costs for the various measures suggested. The large spread of the data, both within and between the different subject groups, should, however, be noted.

DISCUSSION OF RESULTS

The overall conclusion indicated by these data is that drivers are, in general, fairly well satisfied with their ability to perform a route-planning or route-following task effectively. The major constraint on this effectiveness is believed to be unavailability of adequate and accurate route and traffic information.

These deficiencies, which undoubtedly exist, are, however, not sufficient to explain the amount of excess travel due to navigational waste that has been documented by many studies both in the United States (*9*, *10*) and abroad (*11*, *12*). A synthesis of these studies (*3*), combined with a series of empirical studies made as part of the current research effort, resulted in an estimate that such excess travel amounts to 6.4 percent of

the total distance traveled by noncommercial vehicles in the United States and to 12.0 percent of all time spent in such travel.

Furthermore, the distribution of the results achieved by the same subjects in a series of route-planning and route-following exercises (see paper by King in this Record) clearly indicates that route-planning and route-following skills, in many instances, are inadequate for the demands of these tasks.

The optimistic self-rating, the responses concerning the number of routes tried, the relative importance ratings of remedial measures, and the subjects' willingness to pay for such improvements show that the subjects appear to have an insufficient appreciation of the complexities of determining and following optimum routes. Past studies have indicated that recovery of a substantial portion of total navigational waste is definitely feasible. However, the perception of the problem on the part of drivers, and of the public at large, must become considerably more realistic before adequate and appropriate remedial measures can be considered and implemented.

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