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ARROW AIMING IN TRAFFIC GUIDE SIGNS:
A LABORATORY INVESTIGATION

by

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INTRODUCTION

This report summarizes the results of two laboratory experiments designed to yield information regarding the effective utilization of arrows in highway guide signs. The *Manual on Uniform Traffic Control Devices* (1971) makes several specific recommendations with regard to the use of arrows in guide signs which have led to a number of standardized signing practices. For example, the manual recommends horizontal arrows for right angle intersections, vertical upward for straight through movements, and arrows for turns at angles related to the sharpness of the turn. Little more than these suggestions seems to be available to the Traffic Engineer in his attempts to design efficient information displays containing arrows as directional devices. In a recent review of the literature Zajkowski and Satterly (1970) cite a number of studies concerned with the elements involved in the design of signs including shape; dimension and size of the sign; use of words or symbol messages; lettering visibility and legibility; color; reflectorization and illumination. However, few studies were found which dealt with the effective utilization of information on signs containing directional arrows. In two of these studies (Enustun, 1964; Wiley, 1964) it was suggested that vertical upward or upward slanting arrows be used in *advance* of a crossroad or ramp and that *downward* slanting arrows be used at the point of turning or bifurcation. Wiley reports that the use of this principle at the New York World Fair (1964-1965) resulted in fewer mistakes being made by out of state drivers and a reduction in driver complaints. Enustan suggests that the adoption of this principle "on a nationwide basis would eliminate the possibility of misleading the motorist." It is the contention of the present investigator that such use of arrows on informational guide signs may be both valid and highly desirable.

However, before such a recommendation can be implemented, it is necessary to determine the conditions under which directional arrows may be able to enhance the information extraction process. The present investigation was conducted to provide information about several of these important conditions. Specifically, before any modification of present signing techniques is undertaken, it behooves us to examine the possibility that well established stimulus response associations (population stereotypes) may already exist for the materials under consideration. If the existence of stereotypes can be demonstrated, then the changes in these associations caused by signing innovations must be examined. A benefit of such an analysis is that it permits the introduction of changes in associations where disruption will be minimal.

In addition to the analysis of the problem of habit competition, information regarding the relative interpretability of arrow aiming devices in various angular inclinations is of utmost importance in guide sign design. Since such signs are intended to communicate information symbolically, the effectiveness of these symbols must be closely scrutinized. Experiment I of this investigation provides data with respect to both population stereotypes and symbolic meanings. It is clearly not sufficient to examine arrow aiming devices in isolation from the conditions in which they are presently used or will be used in the near future. Certain of these conditions are inevitably experienced under normal driving conditions. Among these are sequential information processing, varying frequencies of information sources, and various distractions. Experiment II was designed to examine several of these variables.

Thus the intent of the present investigation is to provide the preliminary information necessary to the design of a full scale field study of the innovative use of directional arrows in highway guide signs.

Experiment I

The experiment followed a basic 9(arrow inclination) x 2(arrow vertical orientation) x 3(informational content) factorial design with repeated measures on all factors. A description of each of these variables as well as the rationale for their inclusion in the investigation is given below.

Arrow Inclination

The inclusion of this factor in the investigation is obvious in that angular inclination is the basis for communicating directional information in many highway guide signs. The fact that this variable has also been a key element in several current and recommended signing standards constitutes further justification for the examination of its differential effects. The specific levels utilized are given below in Table 1.

Table 1.

Angular Inclinations Used in Experiment I *

Upward Orientation	Horizontal	Downward Orientation
$22\frac{1}{2}^{\circ}$	0°	$202\frac{1}{2}^{\circ}$
45°	180°	225°
$67\frac{1}{2}^{\circ}$		$247\frac{1}{2}^{\circ}$
90°		270°
112°		$292\frac{1}{2}^{\circ}$
135°		315°
$157\frac{1}{2}^{\circ}$		$337\frac{1}{2}^{\circ}$

* 0° refers to an arrow which is horizontal and pointing to the right and the remaining inclinations read counter-clockwise from that position.

The 0° and 180° positions represent perceptual anchor points since they may be construed as belonging to either an upward or downward series. The seven positions of the downward orientation are considered to be the inverted analogies of the seven positions in the upward orientation. It is clear that the number of angles in each of the orientations probably exceeds the number required to communicate directionality to drivers. However, the inclusion of a wide range of arrow positions in this investigation permits an analysis of the unique discriminant power of each position. Thus, recommendations regarding the utilization of particular arrow positions can be made on the basis of their ability to communicate instructions and their confusability with other positions.

Arrow Vertical Orientation

As indicated in Table 1. two major groupings of arrow inclinations were studied. These major groupings refer to the vertical orientations of the arrow head (upward and downward). In light of the Wiley (1964) and Enustun (1964) suggestions and because of existing signing practices in the differential use of arrow vertical orientations, a thorough analysis of this variable was considered necessary. There is the distinct possibility that general upward or downward orientations are capable of producing unique responses. If such response differences exist they may be utilized to enhance driver choice behaviors. If no differences are found, the identification of that fact may aid in preventing unnecessary or superfluous design practices in guide signs. It should be noted that because of their obvious relationship, the angular inclinations were designed to be isomorphic within the vertical orientations in order that possible interaction effects could be studied.

Information Content

Highway guide signs containing arrows are often combined with other types and amounts of highway information. Since such combinations of information seem to be the rule rather than the exception, an examination of the interactions of several selected types of information with directional arrows was made a part of the present investigation. Three types of situations were used. In situation one, directional arrows were presented alone. This type of stimulus permits the establishment of base line behavior to be used in comparative analyses of the other situations. In situation two, the additional information consisted of a route number. This combination of information is often encountered in intercity driving. The specific route number on the signs was selected from a table of random numbers to prevent any previously learned associations from having an effect. The final information situation combined a street name with a directional arrow, a situation often encountered in urban driving. The particular street name was selected on the basis of its relative freedom from specific stimulus-response associations. The three conditions of this variable have been labeled symbolic, numberical, and verbal, respectively.

It has been demonstrated in the psychological literature that stimuli of the type described above interact significantly with the type of response required of the subject to produce stimulus response compatabilities. Thus, because of the fact that these conditions presently exist on the highway and because of their psychological significance, this variable is of particular interest.

Method

Subjects

Ideally, the subject pool for an experiment of this type should represent a sampling of all age ranges from the actual population of drivers. The inclusion of such a range permits the determination of age related differences in the processing of traffic sign information as well as providing a sound foundation for the generalization of results. Table 2. gives the age ranges and frequencies of subjects included in the experiment.

Table 2.

Age and Frequency of Subjects

Age	Frequency
16-25	20
26-35	20
36-45	20
46-55	20

Subjects were selected randomly from among the students and faculty of Wayne State University and from among respondents to advertisements placed in the campus and daily newspapers. The only restrictions placed on the subjects in the investigation were that they had to be a licensed driver and have normal vision either corrected or uncorrected. Each subject was paid $3.00.

Originally, it was planned to include age groups in the 56-65 and 65-over age ranges. However, it proved to be extremely difficult to obtain volunteers in these age groups. Consequently, the data obtained from the several volunteers obtained in these age ranges, were not included in the final analyses. Interestingly, preliminary data analyses suggested that the performances of these individuals was not significantly different from several of the younger age groups and in some instances showed a decided superiority to them.

Apparatus

The equipment used in the experiment was of standard manufacture. Thus, a general description of the equipment configurations and their operations will suffice here. A list and manufacturer's description of the equipment is given in Table 12 of Appendix I.

The equipment was designed to serve three basic functions: the presentation of stimuli, the control of stimulus duration and interstimulus intervals, and the measurement of the subjects' response latencies. The length of stimulus duration was set by determining the approximate amount of time that a directional sign is available to drivers for processing. This measurement, taken at maximum speeds on a freeway, had an approximate average of five seconds. The interstimulus interval was determined by the purely pragmatic consideration of the time necessary to record the subjects' responses. This process required approximately ten seconds.

Upon the start of the experimental sequence the experimenter manually activated the timing sequences. From the time of this activation, a decade interval timer measured a ten second interval. At the end of this interval a second decade interval timer was activated. This second timer served two functions. First, when activated it advanced the slide projector to the next stimulus position. However, in order to assure that the stimulus duration was held constant, a delay between slide change and stimulus exposure was considered necessary. Thus, the second timer was also used to time a .05 second interval, at the end of which a relay activated an electronically timed and controlled tachistoscopic shutter on the slide projector. This shutter exposed the stimulus material for a duration of five seconds. Simultaneously with this exposure, a synchronized passive relay closure on the shutter control activated both a voice key and a standard clock timer which measured the subject's response time. When the subject vocalized his response, the circuit on the voice key was completed, the latency timer stopped, and a new stimulus sequence was initiated. In the interval between the subject's response and a new stimulus, the experimenter recorded both the subject's latency and his categorical response.

The stimuli in the experiment were drawn to half scale, on artboard, in shapes corresponding to the recommendations of the Michigan Manual of Uniform Traffic Control Devices. This hard copy was then photographed against a green background to produce 35mm color transparencies which served as the basic stimuli. The specific content of the slides is discussed in the following section.

Procedure

The basic set of information to which each subject was exposed consisted of depictions of the sixteen arrow inclinations described in an earlier section. This basic set of information was displayed alone (arrow alone), with verbal information (street name), and with numerical information (route number). Thus, each subject was exposed to three sets of sixteen slides. The route number, when used, was identical on all slides and consisted of a two digit number selected at random from a random number table. The street name was also identical on all slides where depicted, and was selected so that familiarity and readability were controlled.

A second set of slides was also prepared to gather information on the ability of different types of arrows to communicate directionality. In this instance, eight major arrow inclinations were combined with four different arrow types. Because in this analysis the interest was primarily on the impact of the arrows rather than the arrow inclinations, the number of inclinations was restricted to the eight considered to be the most unequivocal. Therefore, in this set, only the 0°, 45°, 90°, 135°, 180°, 225°, 270°, and 315° inclinations were used. The arrows used in this comparison are named and scaled according to the standards set by the Michigan State Highway Department. One arrow type was the "Down" arrow. This arrow is a short and straight-shafted arrow whose arrowhead width-to-length ratio considerably exceeds a value of 1.00. The type "A" arrow is relatively short and taper-shafted with a rather broad head having a width-to-length ratio greater than one but less than that of the down arrow. The type "B" arrow is also a taper-shafted arrow whose overall length and arrowhead length are somewhat greater than that of the type "A" arrow. These dimensional changes create a casual impression of greater "arrowness". The final arrow was a type "G" arrow. This arrow is typically used on Michigan Route Marker Arrow Panels. It is a relatively long straight-shafted arrow whose arrowhead width-to-length ratio approached a value of one more closely than any of the other types, creating an even greater impression of "arrowness". Several random orders of the slides were constructed to control order effects. One half of the subjects in each experimental group received one of the random orders and the other half the second random order.

Each of the experimental age groups was constituted so that half of the subjects were male and the other half female. This permits an analysis of the data using sex as a moderator variable.

Another procedural variable of considerable importance deals with the amount of freedom that subjects had in which to make categorical judgments in the present experiment. Since the amount of constraint placed on the subjects' responses can make a significant difference in the type of data one obtains, it was decided to use two conditions of constraint. One half of the subjects were given instructions that they were to respond to each slide presentation with a fixed set of responses. Table 3. lists the responses with which these subjects were to respond.

Table 3.

Response to Stimuli for Constrained Group

A.	Maintain present course
B.	Turn off here (left or right)
C.	Adjust course ahead (left or right) slowly
D.	Adjust course ahead (left or right) quickly

The remaining half of the subjects were given the responses in Table 3. as examples of responses that they could make, but were told that they should give whatever response they felt was appropriate. Thus, this group was unrestricted in their responses. The responses of the subjects under these two conditions of constraint were then compared in terms of both latency and category differences.

Before beginning the experiment, each subject was shown a short set of demonstration slides to insure that he understood the procedure. Each subject was told to respond as quickly as he could after having made his decision and out loud so that the voice key would be activated and the experimenter would have an opportunity to record the response. The complete instructions to the subjects are given in Appendix II.

RESULTS

The results of the latency analysis on the arrow inclinations are summarized in Table 4. An examination of this table reveals that only the main variables of age, $F(3,64) = 3.60$, $p < .05$, information content, $F(2,128) = 16.62$, $p < .001$, and arrow inclination, $F(15,960) = 16.45$, $p < .001$ proved to be significant. A graphical analysis of the age variable revealed that a major portion of the variance contributing to the significance of this variable was due to the 36-45 year age group. More specifically, it was determined that this variance could be attributed to two male subjects whose performances significantly raised the overall performance level of their group. Thus, it is concluded that this significant effect is due primarily to artifacts within a specific group.

The significant effect due to information content seems due to an average latency in the numerical condition which is significantly greater than in either the symbolic condition or the verbal condition, although these two latter conditions do not appear significantly different from each other. Reference to Figure 1 indicates that while higher, the trends in performance related to the numerical condition follow a pattern similar to the other two conditions.

Figure 1 also assists in the analysis of the significant effect due to angular inclinations. From the figure it appears that the 0°, 45°, 90°, 135°, and 180° inclinations consistently produce shorter latencies than the other positions. It should be pointed out that none of these inclinations is in a downward orientation. It would thus appear

Table 4.

Analysis of Variance Summary: Latencies on Arrow Inclination

Source	df	MS	F	p	w^2
A (Objective-Subjective)	1	17.02	1.73		
B (Age	3	35.43	3.60	.05	.0158
C (Sex)	1	.27	.03		
AXB	3	39.40	4.01	.05	.0183
AXC	1	9.58	.97		
BXC	3	37.24	3.76	.05	.0169
AXBXC	3	13.71	1.39		
S	64	9.84			
D (Information Content)	2	45.67	16.62	.001	.0177
AXD	2	3.24	1.18		
BXD	6	1.55	.564		
CXD	2	1.36	.496		
AXBXD	6	3.29	1.19		
AXCXD	2	2.37	.861		
BXCXD	6	1.00	.364		
AXBXCXD	6	.402	.146		
SXD	128	.274			
E (Arrow Inclination)	15	13.67	16.45	.001	.0397
AXE	15	1.81	2.18	.01	.0030
BXE	45	2.00	2.41	.001	.0109
AXBXE	45	1.51	1.81	.01	.0063
CXE	15	.82	.98		
AXCXE	15	.75	.89		
BXCXE	45	.92	1.11		
AXBXCXE	45	1.77	2.14	.001	.008
SXE	960	.83			
DXE	30	2.63	3.35	.001	.0112
AXDXE	30	1.16	1.48	.05	.0023
BXDXE	90	1.09	1.38	.05	.0057
CXDXE	30	.460	.585		
AXBXDXE	90	1.10	1.41	.01	.006
AXCXDXE	30	.84	1.07		
BXCXDXE	90	.87	1.11		
AXBXCXDXE	90	.56	.71		
SXDXE	1920	.79			

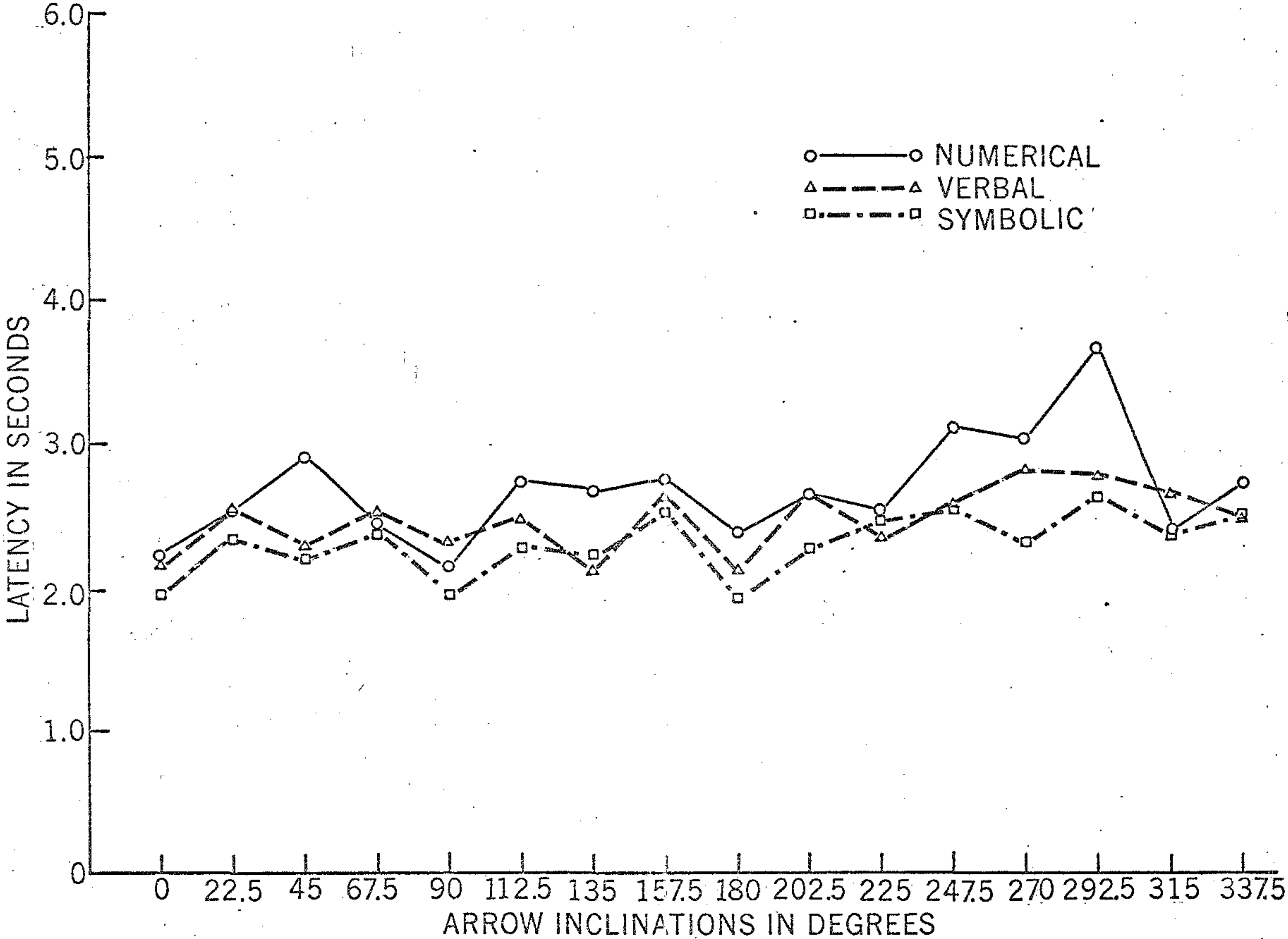


Fig. 1. Response Latency as a Function of Information Content and Arrow Inclination.

that these particular positions produce a perceptual response that one might conclude is a population stereotype. The variability in the remaining positions suggest that, at least in terms of latency data, these positions are more amenable to retraining in the form of new responses.

The results of the frequency of categorical responses tend to confirm the above analysis. These frequency data are broken down into two basic sets of analyses, those for the restricted condition and those for the unrestricted response. We shall deal with the results of the restricted data first. The frequency distributions of the categorical responses to the various arrow inclinations are summarized in Table 5.

Table 6. summarizes the statistical analyses of the frequency data in Table 5. The data in this table clearly reveal that arrow inclinations in an upward and horizontal orientation have specific meanings attached to them. In each of these orientations, there is a single category of response which accounts for most of the responses to that specific stimulus. Examination of Table 6. gives the categorical response of highest frequency while cross reference with Table 5. provides verbal labels for these numerical categories. It is equally clear that downward oriented inclinations are much less consistent in producing stereotypic responses except for the 270^{o} inclination. This data tends to substantiate the latency analyses reported earlier.

In addition to the major frequency analysis three other supplemental analyses were done. These analyses compared

Table 5

Frequency of Responses to Angular Inclinations:

Restricted Response Condition

Angle	No Response	RIGHT Turn (1)	RIGHT Adjust Quickly (2)	RIGHT Adjust Slowly (3)	Maintain Position (4)	LEFT Adjust Turn (5)	LEFT Adjust Quickly (6)	LEFT Adjust Slowly (7)
0°		102	6	9	3			
22.5°	1	25	65	28				
45°		20	84	14				
67.5°		14	89	12	3			
90°		1			158			1
112.5°	1			1	2	15	86	15
135°			2	1	1	18	84	14
157.5°	1		1			29	64	25
180°		1			2	101	7	9
202.5°	4					34	38	44
225°	5		1		3	25	33	53
247.5°	6				8	25	38	43
270°	20			3	132	3	1	1
292.5°	8	19	41	45	5	1	1	
315°	6	25	37	47	2	1	1	1
337.5°	5	31	34	50				

Table 6.

Statistical Analyses of Frequencies to Angular Inclinations: Restricted Response Condition

Inclination	X^2	df	p	Most Frequent Category
0°	231.00	3	.001	1
22.5°	25.23	2	.001	2
45.0°	76.55	2	.001	2
67.5°	100.51	2	.001	2
90.0°	*			4
112.5°	148.11	3	.001	6
135.0°	79.73	2	.001	6
157.5°	23.40	2	.001	6
180.0°	147.90	2	.001	5
202.5°	1.30	2	.70	7
225.0°	11.15	2	.01	7
247.5°	4.83	2	.10	7
270.0°	*			4
292.5°	33.81	2	.001	3
315.0°	6.67	2	.10	3
337.5°	5.44	2	.10	3

*indicates that frequencies concentrated in essentially a single category thus obviating the necessity of an analysis responses to angular inclinations as a function of age group, information content, and gender of the subjects. In the age analyses several significant effects were found. However, there was no consistent trend relating age category to specific response types. As indicated in the latency analyses a majority of the significant effects seemed to be due to a few male subjects in the 36-45 age group, thus suggesting artifactual data. In the gender analyses only a few comparisons were found to be significant, suggesting that gender probably plays no significant role in determining the relationship between response categories and arrow inclinations. Finally, not a single significant effect was found to be due to information content on the signs. These analyses are summarized in Tables 13, 14, and 15 in Appendix III.

The analysis of the unrestricted response condition data tends to confirm the frequency analyses indicated above. In this condition, subjects were permitted to respond with any response they felt was appropriate for a particular stimulus. The responses were then sorted according to general meanings, those having what the experimenter considered to be similar meaning being given a single category name. This process resulted in a list of 30 responses generated by the subjects in this condition. Table 7 contains the frequency distribution of category responses to each angular inclination. An examination of this table reveals that once again inclinations of an upward or horizontal orientation generally resulted in having a single predominant response. It is also

Table 7.

Distribution of Response Frequencies to Angular Inclinations: Unrestricted Response Condition

Response Category		Angular Inclination							
		0°	22.5°	45°	67.5°	90°	112.5°	135°	157.5°
1.	bear L.	2		3		2	91	88	68
2.	bear R.	13	77	92	93	4	3	1	4
3.	turn back								
4.	turn left	2			13		14	15	31
5.	turn R.	98	29	18			2	2	1
6.	prepare to go L.						5	5	5
7.	prepare to go R.		3	2	6			1	
8.	straight thru			1	1	147	1		2
9.	downward L.								
10.	downward R.								
11.	upward L.		1			1	4	6	3
12.	upward R.		4	4	6				
13.	turn back L.								
14.	turn back R.								
15.	down ahead								
16.	this is the St.								
17.	stop, caution								
18.	up straight ahead								
19.	St. straight ahead					1			
20.	exit								
21.	up L., sharply							2	6
22.	up R., sharply		6		1				
23.	prepare to go L.					4			
24.	prepare to go R.					1			
25.	down L., sharply								
26.	down R., sharply								
27.	up L., sharply								
28.	up R., sharply								
29.	Nonsense, No sense								
30.	No response								

Table 7. (continued)

Distribution of Response Frequencies to Angular Inclinations: Unrestricted Response Condition

Response Category		Angular Inclination 180°	202.5°	225°	247.5°	270°	292.5°	315°	337.5°
1.	bear L.	18	43	35	45	2	6	1	
2.	bear R.						38	40	40
3.	turn back					22			
4.	turn left	92	12	25	16	2		1	2
5.	turn right	2	22	2	2	1	20	25	29
6.	prepare to go L.		6	7	8	4		1	
7.	prepare to go R.						4	5	
8.	straight thru		1			84	2	1	8
9.	downward L.		6	10	10	2			1
10.	downward R.						8	11	8
11.	upward L.	1							
12.	upward R.						2		
13.	turn back L.		10	19	15	2		1	
14.	turn back R.				1	1	12	15	10
15.	down ahead				2	12	3		
16.	this is the St.		1	1		2		1	1
17.	stop, caution				1	2			
18.	up straight ahead					2			
19.	St. straight ahead				1				
20.	Exit					3			
21.	up L., sharply	7	15	16	13	1		1	
22.	up R., sharply					1	20	12	22
23.	prepare to go L.							1	
24.	prepare to go R.					1			
25.	down L., sharply								
26.	down R., sharply								
27.	up L., sharply								
28.	up R., sharply								
29.	nonsense, no sense								
30.	no response		4	5	6	13	5	4	5

clear that the downward orientations are much less consistent in the response they evoke both in terms of different responses evoked and the occurrence of several categories which contain a significant number of responses. Of unusual interest, is the fact that several of the inclinations were able to elicit responses of vertical directionality. Once again, the conclusion is reached that upward and horizontal orientations produce a much more stereotyped set of responses suggesting that when design innovations are desired, attention should be focused on downward orientations as they would appear to be more amenable to manipulation. Table 8. summarizes the statistical analyses of these data. It should be pointed out however that the X^2 analyses were done by collapsing low frequency categories into a single "all others" category to meet the requirement of the test. Thus one can get a more accurate picture of the variability in subject responses from an examination of the frequency distributions.

Several supplemental analyses were made on these data. Specifically, X^2 analyses of the relationships between angular inclinations and sex, age, and information content were done. No significant trends were observed in any of these analyses, although a few significant effects were found. These analyses are summarized in Table 16, 17, & 18 of Appendix III. These results suggest that the major source of systematic variance in the experiment is due to angular inclinations of the arrows.

A final set of analyses evaluated the effect of different arrow types on latency of response and categorical responses.

Table 8.

Statistical Analyses of Frequencies to Angular Inclinations: Unrestricted Response Condition

Inclination	X^2	df	p	Most Frequent Category
0°	137.39	2	.001	5
22.5°	54.16	2	.001	2
45.0°	102.20	2	.001	2
67.5°	36.30	1	.001	2
90.0°	112.22	1	.001	8
112.5°	97.56	1	.001	1
135.0°	86.46	2	.001	1
157.5°	30.66	2	.001	1
180.0°	102.22	2	.001	4
202.5°	36.55	5	.001	1
225.0°	19.60	5	.01	1
247.5°	40.80	5	.001	1
270.0°	114.15	4	.001	8
292.5°	17.01	4	.01	2
315.0°	30.20	5	.001	2
337.5°	22.59	4	.001	2

In these analyses some redundancy to earlier data is present, since arrow types were combined with response type, age, sex, and inclinations. However, with regard to inclinations, only the eight major inclinations were used. This allows some assessment of the reliability of the data in the earlier analyses. The analyses of the latency data are given in Table 9. The results of these analyses tend to confirm the results of the latency analysis presented in Table 4. In addition, the interpretation of the significance of these effects in the previous analysis also appear to be valid in this instance. The significance of the arrow type variable is apparently due to a slightly higher mean latency for the "A" and "G" type arrows. These means were 2.67 and 2.58 secs respectively as compared to 2.34 and 2.49 secs for the "B" and "D" type arrows. Although these differences achieve statistical significance, one can only conjecture about their practical significance.

The results of the frequency of category responses to inclinations as a function of arrow type indicate that arrow type has no significant impact. Once again, one is led to the conclusion that the most significant source of variance in these analyses is due to the arrow inclinations. The results of the frequency analyses for both the restricted and unrestricted response conditions are given in Table 10.

Table 9.

Analysis of Variance Summary: Latencies on Arrow Types

Source	df	MS	F	p	w^2
A (Objective-Subjective)	1	40.209	2.768		
B (Age)	3	60.565	4.169	.05	.0234
C (Sex)	1	17.059	1.174		
AXB	3	99.986	6.883	.005	.0435
AXC	1	65.196	4.488	.05	.0036
BXC	3	85.653	5.897	.01	.0362
AXBXC	3	50.339	3.465		
S	64	14.526			
D Arrow Type)	3	13.519	3.774	.05	.0051
AXD	3	17.684	4.937	.01	.0072
BXD	9	17.741	4.952	.005	.0217
CXD	3	28.252	7.887	.005	.0126
AXBXD	9	17.382	4.852	.005	.0211
AXCXD	3	14.871	4.151	.01	.0058
BXCXD	9	21.103	5.891	.005	.0268
AXBXCXD	9	20.764	5.796	.005	.0263
SXD	192	3.582			
E (Arrow Inclination)	7	23.564	19.091	.005	.0266
AXE	7	13.178	1.067		
BXE	21	13.984	1.133		
AXBXE	21	1.406	1.139		
CXE	7	2.363	1.914		
AXCXE	7	.888	.719		
BXCXE	21	1.765	1.430		
AXBXCXE	21	2.911	2.358	.01	.0060
SXE	448	1.234			
DXE	21	1.967	2.434	.01	.0041
AXDXE	21	3.743	4.632	.005	.0105
BXDXE	63	.717	.888		
CXDXE	21	.682	.845		
AXBXDXE	63	.669	.828		
AXCXDXE	21	1.091	1.351		
BXCXDXE	63	.672	.832		
AXBXCXDXE	63	.795	.984		
SXDXE	1344	.808			

Table 10.

Frequency of Response Analyses:
Arrow Type X Response Category

Inclination	X^2	df	p	Most Frequent Category
	Restricted Response Condition			
0°	1.61	6	.70	1
22.5°	2.95	9	.98	1-2
45.0°	.32	3	.98	2
90.0°	*	*	*	4
135.0°	3.74	6	.70	6
180.0°	.60	4	.98	5
270.0°	*	*	*	4
315.0°	.80	6	.98	2-3
	Unrestricted Response Condition			
0°	6.88	6	.50	5
45.0°	6.50	6	.50	2
90.0°	*	*	*	8
135.0°	2.99	3	.50	1
180.0°	1.40	3	.80	4
225.0°	8.33	12	.80	6
270.0°	1.89	6	.95	8
315.0°	11.13	12	.70	5

*the majority of responses fall in a single category thus obviating the need for an analysis. The category of response are the same as those of Tables 5 and Table 7 respectively.

DISCUSSION

The general results of Experiment I allow several conclusions to be reached. First, it would seem that arrow inclinations have developed, through past practice and experience, some rather consistent meanings for drivers. This generalization applies particularly to arrows in an upward or horizontal orientation. Presumably, this is because more signs are experienced in this type of orientation. Even within this sweeping statement certain of the inclinations consistently produce very stable categorical responses. One can only suppose that inclinations which are not quite as stable are not experienced as often or are easily confused with other orientations. Thus it might be prudent to consider the possibility of using only those inclinations which are relatively stable in our present signing programs. The inclinations which do not elicit stereotypic responses might then be used for innovations in signing techniques such as that suggested by Wiley (1964) and Enustun (1964). That is, the downward oriented arrows, since they are more variable in the responses elicited, would in all probability be more susceptible to innovations in signing practices. In addition, these inclinations have a greater potential for change through driver education programs.

Several other conclusions seem to follow from the results. Specifically, it seems reasonable to conclude that categorical judgments are independent of sex or age of the driver. This is as it should be if most drivers are driving as the designers of the information systems intended. There are some slight differences in latencies of response of course, but these are not of practical significance and are to be partially expected due to maturational differences.

The fact that arrow type produced no significant differential effect was somewhat surprising but nevertheless heartening, because it suggests that categorical responses are independent of interactions with purely physical characteristics of the arrows. This fact allows the sign designer a bit more freedom in the physical configuration of signs.

A word of caution should be added at this point. The research reported in Experiment I is purely laboratory in nature. It would not be prudent to suggest that the results are definitive in nature. It is suggested that a reliability and validity check of the data should be done and combined with field tests before the data are incorporated in future signing work. However, it is felt that results clearly indicate that such data can be of considerable assistance in future signing practices. In the following sections, Experiment II will be described. This experiment is an attempt to extend the findings of Experiment I and provide additional insights into the utility of directional arrows in highway signs.

Experiment II

Basic Design

The basic design of this experiment was a 2(experience) X 2(distraction) X 2(frequency) factorial with repeated measures on frequency. This basic design allows the assessment of the basic arrow aiming devices when used in various combinations rather than singularly. In particular, an attempt was made to identify the sequences of arrow aiming which produce the least amount of variability in categorical responses and the fastest reaction times. The rationale for including each of the variables is given below.

Experience

Experience is an integral part of any learning situation and therefore was included in this experiment to evaluate its impact on categorical responses to angular inclinations in sequence. To gain some insight into the effects of this variable, two levels of experience were included in the experiment. In the first level of experience, naive subjects were required to make judgments of signs with only a brief introduction to the experiment. This type of condition allowed the assessment of the effects of uninstructed learning on information utilization. Very often it is possible to instruct subjects as to the meaning of symbolic messages before they actually gain any real experience with the system. Therefore, as the second level of experience, the design included a group of subjects who were instructed as to the intended meaning of the symbol system before they were actually required to use the system. A comparison of the levels of performance under the two levels of experience would thus permit some degree of generalization about the utility of an instructional system to accompany design changes in highway marking systems.

Distraction

It is obvious that drivers do not experience information in a completely noise-free environment and therefore, it was considered desirable to evaluate the effects of distraction on information processing. Two levels of distraction were included. The first level used no distraction. Thus, half the subjects performed the task with no secondary duties to perform. The remaining subjects were distracted by a secondary task which was performed simultaneously with the primary task of the experiment. The secondary task consisted of following a pursuit rotor track at 30 RPM with a stylus. The subject in this latter condition was instructed that his performances on both the primary and secondary tasks were being assessed and therefore, he should be as accurate and quick as possible on both tasks. This instruction was given to the subjects to suggest to them that the interaction between vehicle control and information processing was critical and of unique interest in itself.

Frequency of Symbols

The impact of the frequency of stimulus presentation is of obvious importance. The notion here is that as the quantity of advance information increases the more likely the driver is to make accurate choices. Two levels of frequency were used in the experiment. It was felt that sequences of two and four stimuli would be adequate to assess the effect of this variable. The inclusion of this variable in the design also allows the assessment of the effects of interactions of frequency, with distraction, experience, and arrow inclinations.

Arrow Sequences

The general purpose of both the experiments was to examine possible arrow orientations for indicating immediate turning points on the highway situation after a sequence of advance information arrows has been experienced. In Experiment I, it was demonstrated that a horizontal arrow of either 0° (right) or 180° (left) clearly connotes a turning point. Arrows which also connoted such a driving action were the upward oriented 45° (right) and 135° (left) arrows and the downward oriented 225° (left) and 315° (right) inclinations. Thus, for comparative purposes each of the above arrow inclinations (horizontal, upward and downward) were combined with all possible logical advance information sequences. However, the advance information possibilities were restricted to those inclinations which were judged as those producing the most unequivocal responses. Thus the advance information slides were selected from among the 0°, 45°, 90°, 135°, 180°, 225°, 270°, or the 315° inclinations. These considerations thus require that twenty-four two arrow sequences and ninety-six four arrow sequences be used in the experiment. This methodology permits the comparison of the effectiveness of different sequences of information in connoting certain desired responses. A complete description of these sequences is given in Table 19. Appendix IV.

Subjects

The subjects in this experiment consisted of forty subjects randomly selected from age levels and driving experience. All subjects were licensed drivers and had not participated in Experiment I. Thus, the research employed 4 basic groups of 10 each Ss based upon the experience (2) X distraction (2) variables since all Ss received all levels of the other factors. The proportion of male and female subjects was held constant in all groups. Each subject received a payment of $4.00 for his participation in the experiment.

Methodology

As indicated above, all subjects experienced all information sequences. The equipment and methodology was identical to that used in Experiment I with a single exception. The distracted groups were required to maintain a stylus in contact with a rotating disk on a Lafayette Instruments Rotary Pursuit Meter. Each sequence of slides was set off from the other sequences by means of a blank interval. The order of sequences to be presented was randomized and half the subjects in each of the groups received one random order while the other half received a different random order. Subjects were given a five minute rest between each series of sequences which was timed to coordinate with slide tray changes.

The dependent variables in this experiment consisted of latency of response and subjective categorical response as in Experiment I. The objective response condition was eliminated from this experiment since it essentially duplicates the subjective condition and in most cases is not as inclusive.

The subjects in the experiment were instructed that the experiment was designed to assess the interaction of effects of driving to be simulated in this experiment by the pursuit rotor and highway information processing to be simulated by the slides. It was stressed that we were concerned with the speed and accuracy of performance on both these tasks. The complete instructions to subjects are given in Appendix II.

RESULTS

The initial analysis of frequency data consisted of an examination of the effects of distraction and information about arrow meanings on the categorical responses to the various arrow sequences. To accomplish this analysis, a separate chi square analysis was done for each sequence utilizing the distraction and information conditions as the categories of the contingency table. The data consisted of the different number of categorical responses elicited under each of the conditions. Only two of the 120 analyses reached significance. The frequencies and the chi square tests are summarized in Table 20 of Appendix V. One must conclude from these results that in the present study neither distracting the subjects nor informing them as to the meanings of arrows significantly affect the subjects' categorical responses.

The 120 sequences were then rank ordered in terms of the number of *different* categorical responses elicited. It would seem reasonable to assume that those sequences which elicit the *fewest* different categories are the sequences which most probably are eliciting population stereotypic responses. Arbitrary criteria were then established by which to separate the "best" sequences from the others. These criteria were empirically established and were determined to be six or fewer different categories for the two-arrow sequences and thirteen or fewer different categories for the four-arrow sequences. No attempts were made to establish the "correctness" of the categories. The sequences which met these criteria are given in Table 11 along with the mean number of categories elicited and the mean latency of response to the sequence. A complete description of each of these numbered sequences can be found in Table 19 of Appendix IV. Several additional analyses of the criterial sequences were then done to determine their essential characteristics. A chi square of the right-left orientation revealed no significant differences in the frequency with which these orientations occurred in the sequences, $X^2(1df) = .0286$. Similarly an analysis of the vertical orientation in the sequences revealed no significant differences in the frequency with which these orientations were represented in the advance information portions of the sequences, $X^2(1df) = 2.9412$. However, several additional analyses revealed some interesting characteristics of the sequences included in the criterial group. An analysis of the end arrows of the sequences revealed that upward orientations, including the horizontal, were significantly more frequent than downward orientations, $X^2(1df) = 30.12$, $p < .001$. Finally, it was determined that the horizontal orientation in the end arrows occurred in the criterial group more frequently than any other type of orientation, $X^2(1df) = 6.4286$, $p < .025$. Thus, one can reach the conclusion that the driving population represented by the sample in this investigation seems to have established population stereotypes for the end arrow in guide sign sequences. Specifically, it would appear that upward oriented and horizontal end arrows are most firmly established in terms of driver expectations.

Table 11.

Summary of a Mean Number of Categories
and Mean Latencies for Sequences Reaching Criterion

Sequence *	Mean Number of Categories	Mean Latency
1	5.00	1.80
4	4.25	1.74
7	5.25	1.86
10	5.00	1.79
11	5.00	1.78
13	5.00	1.81
16	5.50	1.72
22	5.00	1.88
25	8.75	1.64
27	10.50	1.68
28	9.75	1.67
31	9.25	1.71
37	10.25	1.69
38	10.00	1.82
43	9.75	1.76
44	10.25	1.73
46	10.00	1.92
49	10.50	1.64
50	10.50	1.76
51	10.25	1.68
55	9.75	1.72
56	9.75	1.77
57	10.25	1.67
61	9.75	1.77
62	10.75	1.81
68	9.75	1.87
75	11.50	1.90
79	12.00	1.93
82	11.50	1.74
97	11.00	1.72
98	10.50	1.79
103	11.00	1.81
106	10.75	1.76
112	12.00	1.75

*complete description of sequences can be found in Table 19 of Appendix IV.

The analysis of response latencies was restricted to the sequences which had met the frequency criteria discussed earlier. However, a complete summary of the means and standard deviations for all sequences as a function of information and distraction conditions is given in Table 21 of Appendix V. No significant differences in latencies were found as a function of sequences in the criterion group, $F(33,102) = .8509$. In addition, a t test for unequal sample sizes revealed no significant differences in latencies between the two-arrow and four-arrow sequences, $t(164df) = 1.2079$. Finally, an analysis of variance revealed that the distraction variable, $F(1,132) = 12.00$, $p < .01$ and the information variable, $F(1,132) = 178.00$, $p < .01$ both were significant. In the case of the distraction variable, the mean for the distracted condition was 1.74 secs. as opposed to 1.80 secs. for the undistracted condition. This suggested the possibility that in the experimental situation the dual tasks of following a target and extracting information from highway signs caused the subject to more efficiently distribute his attention, resulting in a lower latency for the distracted group. The fact that the mean latency for the group which was instructed as to the meanings of arrows was 1.88 secs. as opposed to 1.65 secs. for the uninstructed group is interesting and open to some interpretation. One explanation for such a finding is that the subjects may have had stereotypic responses to the arrows prior to participating in the experiment and that the meanings established by the experimenter conflicted with these stereotypes thus raising the mean latency. A second explanation for this finding is that the subjects given specific meanings to use took longer to make their response because they attempt to check their choice against available response before overtly stating their choice. This finding implies that if one attempts to change information on highway signs and then attempts to modify drivers' responses through educational programs, it may be reasonable to expect an increase in response latencies until the new stimulus response associations are thoroughly learned.

SUMMARY

The results of the two experiments discussed in this report provide considerable information with respect to the use of arrows in route guide signs. Experiment I demonstrated that age or sex have little impact on categorical responses to various angular inclinations. In addition it was found that the type of arrow used in the experiment had little effect on categorical responses and only marginal effects on response latencies. On the other hand, it was determined that upward orientations were consistently related to more stereotypic responses while downward orientations produced significantly more variety in responses. A detailed examination of this data revealed that the arrow inclinations occupying the major upward compass points produced faster response latencies and more unequivocal categorical responses. It was also found that arrow inclinations combined with numerical information on the guide sign produced higher latencies than when the arrows are combined with verbal information or are presented alone. Data are also presented which permit an inspection of the relationship between specific categorical responses and the various angular inclinations. Finally, it was found that permitting the subject unrestricted latitude in making his categorical responses provides a more adequate data base than does forcing responses into a set of fixed categories.

In Experiment II attention was focused on the effect of various arrow inclinations in sequences. The analyses revealed

that upward oriented sequences produce the fewest different categorical responses. It was also determined that the end arrow of the sequences is significantly more often in the horizontal orientation in the criterion sequences. No significant differences were found between right and left oriented sequences. Distracting subjects from the primary task or providing them with specific meanings for the angular inclinations appeared to have no effect on categorical responses. The latency data indicated no significant difference between individual sequences or between two-arrow and four-arrow sequences. Finally, it was determined that both the distraction variables and instruction variables significantly affected response latencies.

In conclusion, the data of this report demonstrate the existence of stereotypic driver responses to guide sign arrows in upward orientations. The results also suggest that the innovative use of arrows in guide signs should be concentrated in downward orientations. However, the abstract nature of the stimuli in the present investigation requires the implementation of the recommendations made by Zajkowski and Satterly (1970) for a laboratory study utilizing slides of actual highway scenes and a field test of the proposed signing methods. Putting these recommendations into effect will permit a validity assessment of the data obtained in the present investigation and an examination of the effects of differential roadway and intersection guide sign placement as suggested by Enustan (1964) and Wiley (1964).

Appendix I

Equipment used in the Experiment.

TABLE 12

Equipment used in Experiment I and II

Quantity	Manufacturer		Unit
1	Gerbrands	G1168	Electronic Tachistoscopic Shutter with Timer
1	Gerbrands	G1169	Kodak Carousel 800 Projector
2	Hunter	111C	Decade Interval Timer
1	Hunter	150	Self Holding Relay
1	Lafayette		Pursuit Rotor
1	Lafayette	6602A	Voice Response Time Control
1	Lafayette	5661ADW	Stop Clock

Appendix II

Instructions to Subjects in Experiments I and II

Instructions for Experiment I

You are going to be participating in an experiment which deals with highway safety. Generally what we are trying to determine is the extent to which licensed drivers agree on the meanings of certain types of traffic signs. You will be shown a series of slides which depict highway signs as they might actually be experienced on the highway. There will be a number of sets of these slides. After each set there will be a slight pause while we change to the next set and you will be able to take a rest during these pauses. Your task will be relatively simple. As soon as each slide appears we want you to determine what action the sign indicates that you should take.

A. Instructions for restricted alternatives

If you will look at the card we have provided you will see the choices of response that you have. For example your choices are

A. Maintain present course
B. Turn off here (left or right) Note: emphasize that the left or right must be included
C. Adjust course ahead (left or right) slowly
D. Adjust course ahead (left or right) quickly

B. Instruction for nonrestricted group

We would like you to indicate whatever the sign Means To You. For example it could mean

A. Maintain present course
B. Turn off here (left or right) Note: Do not show card.
C. Adjust course ahead (left or right) slowly
D. Adjust course ahead (left or right) quickly

These are only a few of the possibilities of course, but we do want you to clearly indicate what the signs mean to you. It is extremely important that you supply us with as exact a meaning as possible.

As soon as each slide appears we would like you to make your decision as quickly as possible. Once you have made your decision please report your answer out loud INTO THE MICROPHONE IN FRONT OF YOU. Please speak clearly, distinctly and in a normal tone of voice. As your response will stop a timer and must also be hand recorded. If possible, please avoid a cough or unnecessary talking into the microphone when a slide is on the screen as this might accidently activate the device controlling the timing. Once again, in your responses always indicate exactly what action the sign connotes. That is, you should always indicate the direction and the type of action. The speed and accuracy of your responses are both critical. Therefore we would like you to make your responses as quickly and accurately as possible.

Do you have any questions?

Before we get started with the main body of the experiment I will show you some demonstration slides so that you can see the kind of slides you will be asked to respond to--once again even with these slides respond as accurately and quickly as you can.

Instructions for Experiment II

Instructions to be read to all Subjects

You are going to be participating in an experiment which deals with highway safety. In this specific instance, we are going to be examining the drivers ability to extract information from highway signs. Naturally, we will not be using a real vehicle or highway signs in the experiment but the tasks we have chosen for the experiment do contain the essential elements of the actual tasks we are attempting to examine. For example, instead of actual highway signs, you will be shown several series of slides arranged in meaningful orders, but not necessarily as they are seen on highways. There will be a slight pause between each set of these slides. Your task will be relatively simple, with regard to these slides. As soon as each slide appears we want you to tell us what the sign means to you. For example the sign could mean-

1. Stop
2. Yield
3. Turn here

Let me emphasize that these are only examples and we want you to indicate whatever the sign means to you.

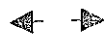
As soon as each slide appears we would like you to make your decision as quickly as possible. Once you have made your decision please REPORT YOUR ANSWER OUT LOUD INTO THE MICROPHONE IN FRONT OF YOU. Please speak clearly, distinctly, and in a normal tone of voice. If possible, please avoid a cough or unnecessary talking into the microphone when a slide is on the screen as this might accidently activate the timing device. Once again, in your responses indicate exactly what action the sign connotes. That is, you should always indicate the DIRECTION AND THE TYPE OF ACTION. The speed and accuracy of your responses are both critical. Therefore we would like you to make your responses as quickly and accurately as possible.

Additional Instructions-Distraction group only

We are of course interested in the interaction between visual task capabilities and the ability to drive the vehicle. Thus, while you are seeing the slides we will ask you to perform a second and simultaneous task, which simulates the actual vehicle control task. As you will note, on the table in front of you is an apparatus which somewhat resembles the turntable on a phonograph. Your task is to take this stylus (an L-shaped rod on a hinged handle) and holding the handle, keep the metal tip on this little disc as it revolves. As you can see, this requires some degree of coordination as you must respond to each slide as it appears while doing your best to keep the stylus on the target. I wish to emphasize that we are concerned with your ability to perform of both of the tasks. Your performance on each of the tasks will be automatically on record.

Additional instructions for instructed group only

Before we begin the experiment I would like to take a few moments to explain the information you will be seeing on the slides. On each of these slides you will see a guide arrow of a particular kind. In preliminary research we have been able to establish the general meanings of these signs. (Give subject card with arrow inclinations and general categorical responses on it). If you will look at this card we can go over it together and examine these meanings.

Arrow Inclination		General Categorical response
1.		Straight Ahead
2.		Keep left (right)
3.		Turn left (right)
4.		Exit left (right
5.		Thru Traffic

All of the slides that you will see contain one of these arrows and we will require you to respond to each slide. However, I would like to emphasize once again, that we want you to indicate what each slide means to you. So give whatever you believe to be an appropriate response to each slide. Do you have any questions?

Appendix III

Statistical Analyses

TABLE 13

Frequency Analysis: Age X Arrow Inclination

Restricted Response Condition

Angle	x^2	df	p
0	*	*	*
22.5	16.16	6	.02
45	20.85	3	.02
67.5	9.53	1	.05
90	*	*	*
112.5	*	*	*
135	*	*	*
157.5	13.11	6	.05
180	*	*	*
202.5	19.34	6	.01
225	8.98	6	.20
247.5	5.86	6	.50
270	*	*	*
292.5	10.25	6	.20
315	8.49	6	.30
337.5	16.28	6	.02

Note.-- * means that majority of responses have fallen in a single category.

TABLE 14

Frequency Analysis: Sex X Arrow Inclination

Restricted Response Condition

Angle	x^2	df	p
0	1.05	1	.50
22.5	7.04	2	.05
45	1.99	2	.50
67.5	1.71	2	.50
90	*	*	*
112.5	2.15	2	.50
135	.25	2	.90
157.5	.93	2	.70
180	4.47	1	.05
202.5	2.10	2	.50
225	18.15	2	.01
247.5	10.26	4	.05
270	.08	1	.80
292.5	10.88	2	.01
315	11.66	2	.01
337.5	.36	2	.90

Note.-- * means that majority of responses have fallen in a single category.

TABLE 15

Frequency Analysis: Information Content X Arrow Inclination

Restricted Response Condition

Angle	x^2	df	p
0	1.58	2	.50
22.5	2.03	4	.80
45	2.30	4	.70
67.5	1.12	2	.70
90	*	*	*
112.5	.87	4	.98
135	3.28	4	.70
157.5	1.03	4	.95
180	.49	2	.80
202.5	6.40	4	.20
225	2.29	4	.50
247.5	2.28	4	.70
270 L	.11	2	.95
270 R	.83	2	.70
292.5	1.79	6	.95
315	2.25	4	.70
337.5	6.61	4	.20

Note.-- * means that majority of responses have fallen in a single category.

TABLE 16

Frequency Analysis: Age X Arrow Inclination

Unrestricted Response Condition

Angle	x^2	df	p
0	13.58	3	.01
22.5	11.22	6	.10
45	.14	3	.99
67.5	7.40	3	.10
90	*	*	*
112.5	3.89	3	.30
135	4.01	3	.20
157.5	2.56	6	.90
180	7.49	3	.10
202.5	17.97	6	.01
225	22.47	9	.01
247.5	23.32	6	.01
270	33.95	9	.01
292.5	16.41	9	.10
315	19.48	6	.01
337.5	14.34	6	.05

Note.-- * means that majority of responses have fallen in a single category.

TABLE 17

Frequency Analysis: Sex X Arrow Inclination

Unrestricted Response Condition

Angle	x^2	df	p
0	9.78	1	.01
22.5	3.06	2	.30
45	2.22	2	.50
67.5	3.08	2	.30
90	*	*	*
112.5	.70	2	.80
135	1.90	2	.50
157.5	2.16	2	.50
180	4.52	2	.20
202.5	36.02	5	.01
225	6.94	5	.30
247.5	12.81	5	.05
292.5	12.98	3	.01
315	6.06	5	.50
337	6.66	4	.20

Note.-- * means that majority of responses have fallen in a single category.

TABLE 18

Frequency Analysis: Information Content X Arrow Inclination

Unrestricted Response Condition

Angle	x^2	df	p
0	2.42	2	.30
22.5	2.24	4	.70
45	4.36	4	.50
67.5	.69	2	.80
90	*	*	*
112.5	1.09	2	.70
135	2.39	2	.50
157.5	4.68	4	.50
180	.34	2	.90
202.5	3.22	6	.80
225	2.68	6	.90
247.5	1.11	4	.90
270	42.61	2	.01
292.5	1.92	8	.99
315	1.73	4	.80
337.5	2.88	6	.90

Note.-- * means that majority of responses have fallen in a single category.

Appendix IV

Experimental Sequences

TABLE 19

Experimental Sequences

Sequence	Angular Inclinations in Degrees 1.	2.	3.	4.
1	45	0		
2	45	315		
3	45	45		
4	90	0		
5	90	315		
6	90	45		
7	315	0		
8	315	45		
9	315	45		
10	270	0		
11	270	45		
12	270	315		
13	135	180		
14	135	225		
15	135	135		
16	90	180		
17	90	225		
18	90	135		
19	225	180		
20	225	135		
21	225	225		

Visual Representation 1. 2. 3. 4.

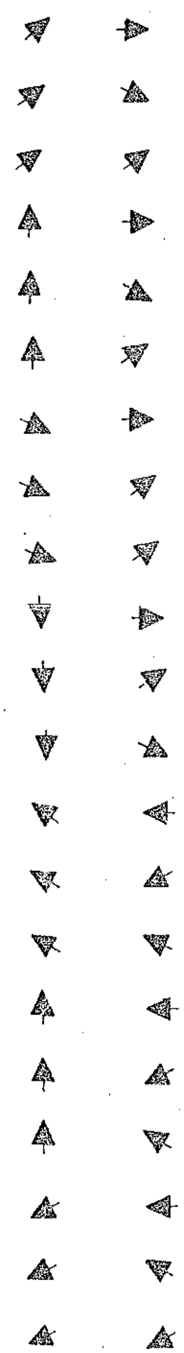


TABLE 19

Continued

Sequence	Angular Inclination In Degrees 1.	2.	3.	4.
22	270	180		
23	270	135		
24	270	225		
25	90	90	90	180
26	135	135	135	180
27	135	135	135	135
28	90	90	90	135
29	90	90	90	225
30	135	135	135	225
31	135	90	90	180
32	135	135	90	180
33	135	90	90	135
34	135	135	90	135
35	135	90	90	225
36	135	135	90	225
37	90	135	90	180
38	90	135	135	180
39	90	135	90	135
40	90	135	135	135
41	90	135	90	225
42	90	135	135	225

Visual Representation 1. 2. 3. 4.

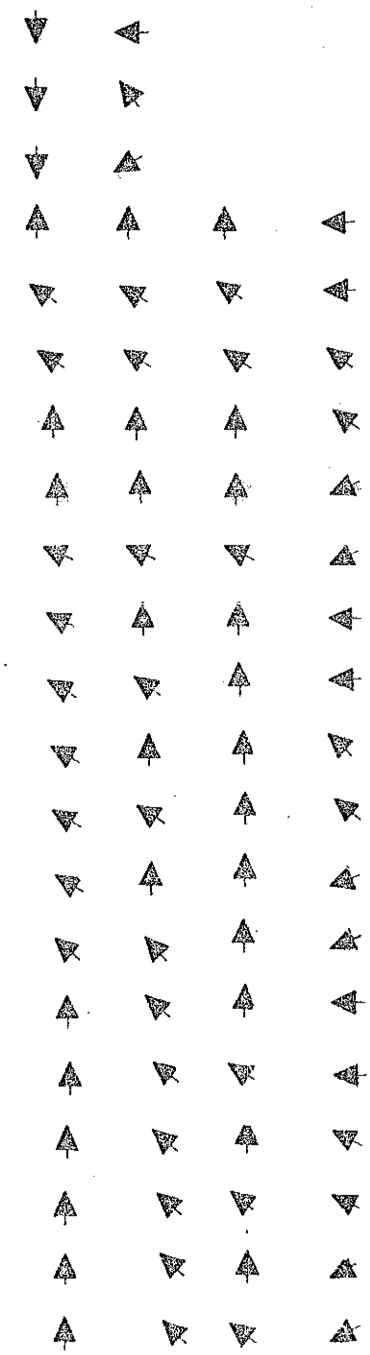


TABLE 19

Continued

Sequence	Angular Inclinations In Degrees 1.	2.	3.	4.	Visual Representation 1.	2.	3.	4.
43	90	90	135	180				
44	135	90	135	180				
45	90	90	135	135				
46	135	90	135	135				
47	90	90	135	225				
48	135	90	135	225				
49	90	90	90	0				
50	45	45	45	0				
51	90	90	90	45				
52	45	45	45	45				
53	90	90	90	315				
54	45	45	90	315				
55	45	90	90	0				
56	45	45	90	0				
57	45	90	90	45				
58	45	45	90	45				
59	45	90	90	315				
60	45	45	45	315				
61	90	45	90	0				
62	90	45	45	0				
63	90	45	90	45				

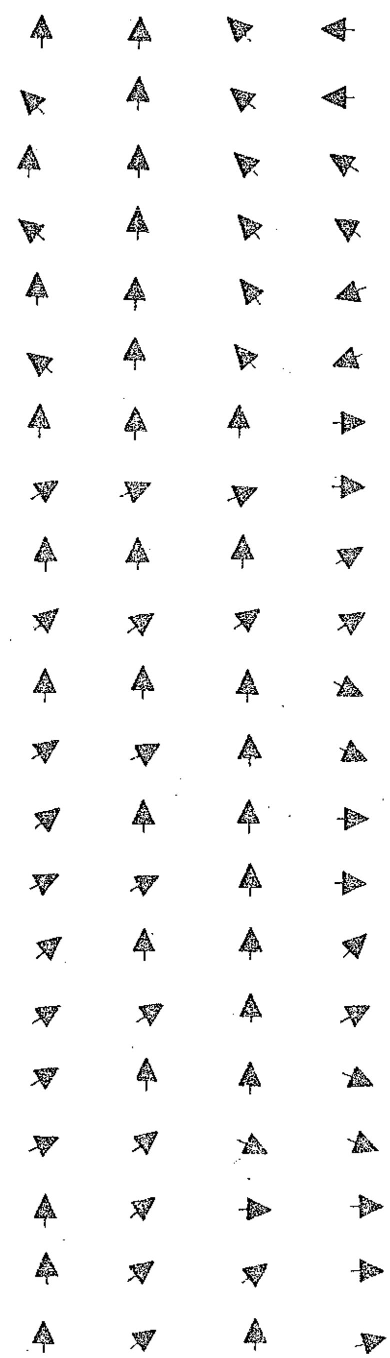


TABLE 19

Continued

Sequence	Angular Inclination In Degrees 1.	2.	3.	4.
64	90	45	45	45
65	90	45	90	315
66	90	45	45	315
67	90	90	45	0
68	45	90	45	0
69	90	90	45	45
70	45	90	45	45
71	90	90	45	315
72	45	90	45	315
73	270	270	270	0
74	270	270	270	315
75	270	270	270	45
76	315	270	270	0
77	315	270	270	315
78	315	270	270	45
79	270	315	270	0
80	270	315	270	315
81	270	315	270	45
82	270	270	315	0
83	270	270	315	315
84	270	270	315	45

Visual Representation 1. 2. 3. 4.

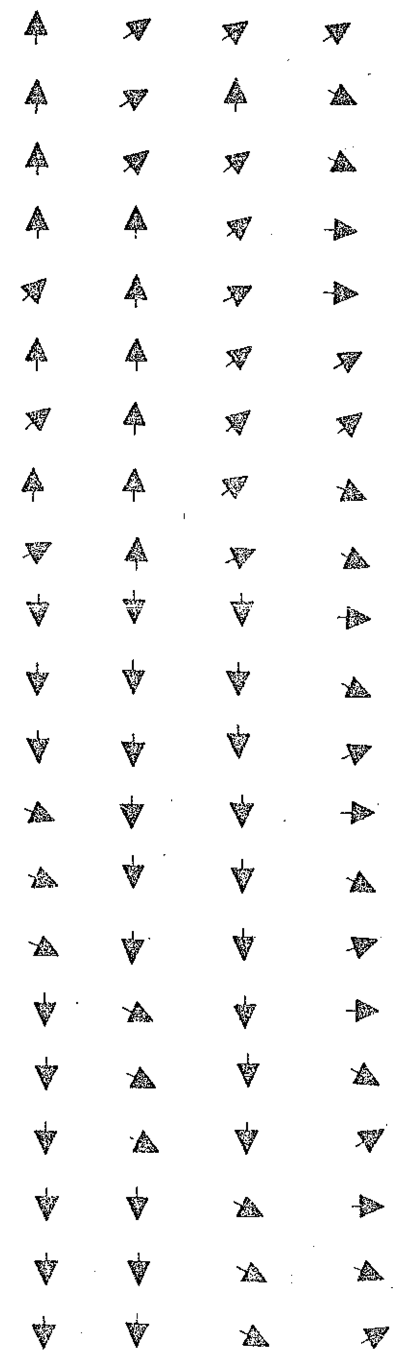


TABLE 19

Continued

Sequence	Angular Inclinations In Degrees 1.	2.	3.	4.	Visual Representation 1.	2.	3.	4.
85	315	315	315	0				
86	315	315	315	315				
87	315	315	315	45				
88	315	315	270	0				
89	315	315	270	315				
90	315	315	270	45				
91	270	315	315	0				
92	270	315	315	315				
93	270	315	315	45				
94	315	270	315	0				
95	315	270	315	315				
96	315	270	315	45				
97	270	270	270	180				
98	270	270	270	135				
99	270	270	270	225				
100	225	270	270	180				
101	225	270	270	225				
102	225	270	270	135				
103	270	225	270	180				
104	270	225	270	135				
105	270	225	270	225				

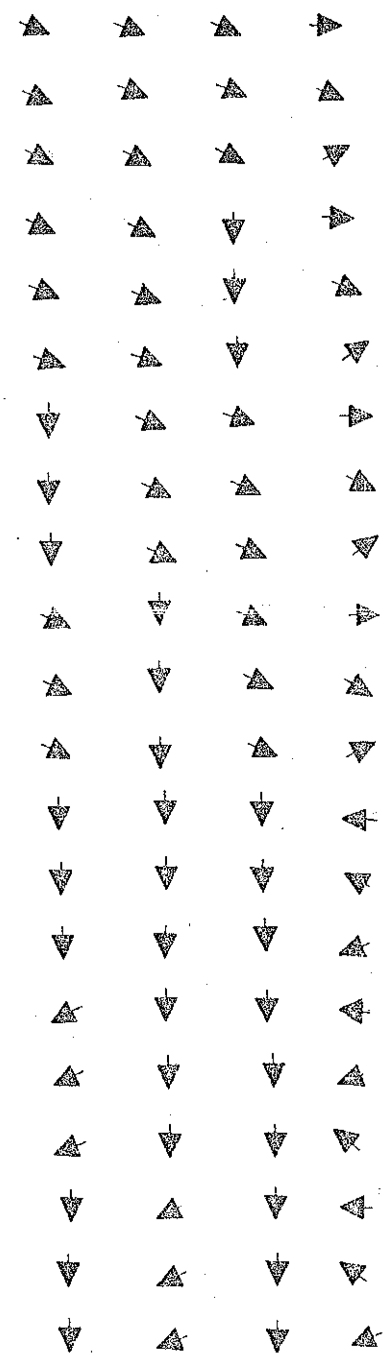


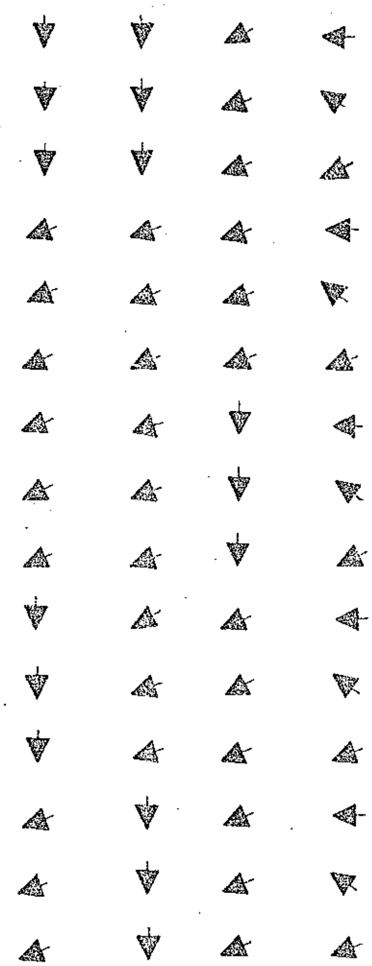
TABLE 19

Continued

Sequence	Angular Inclinations In Degrees 1.	2.	3.	4.
106	270	270	225	180
107	270	270	225	135
108	270	270	225	225
109	225	225	225	180
110	225	225	225	135
111	225	225	225	225
112	225	225	270	180
113	225	225	270	135
114	225	225	270	225
115	270	225	225	180
116	270	225	225	135
117	270	225	225	225
118	225	270	225	180
119	225	270	225	135
120	225	270	225	225

Visual Representation

1. 2. 3. 4.



Appendix V

Statistical Analyses Experiment II

TABLE 20

Number of Different Categorical Responses

to Arrow Sequences

Sequence	Number of Categories				x^2	df	p
	Undistracted		Distracted				
	uninformed	informed	uninformed	informed			
1	5	6	5	4	.20	1	ns
2	8	7	7	6	.00	1	ns
3	8	6	6	4	.02	1	ns
4	3	4	4	4	.08	1	ns
5	8	5	5	6	.62	1	ns
6	8	5	5	4	.08	1	ns
7	6	4	5	6	.44	1	ns
8	10	7	7	5	.00	1	ns
9	9	5	8	6	.15	1	ns
10	6	4	4	6	.80	1	ns
11	6	5	4	5	.20	1	ns
12	8	5	5	5	.30	1	ns
13	6	5	5	4	.00	1	ns
14	8	6	7	5	.00	1	ns
15	8	8	8	5	.39	1	ns
16	5	4	3	4	.25	1	ns
17	8	3	5	5	1.15	1	ns
18	8	5	4	4	.30	1	ns
19	9	5	4	6	1.39	1	ns
20	9	6	8	5	.01	1	ns

TABLE 20

Continued

Sequence	Number of Categories				x^2	df	p
	Undistracted		Distracted				
	uninformed	informed	uninformed	informed			
21	10	6	8	6	.08	1	ns
22	5	5	5	5	.00	1	ns
23	7	6	5	4	.00	1	ns
24	8	5	6	6	.33	1	ns
25	11	8	8	8	.22	1	ns
26	14	14	12	8	.47	1	ns
27	12	13	9	8	.08	1	ns
28	13	9	9	8	.00	1	ns
29	14	9	7	11	1.95	1	ns
30	17	12	17	9	.26	1	ns
31	11	10	8	8	.02	1	ns
32	14	10	10	9	.13	1	ns
33	17	11	12	7	.02	1	ns
34	15	11	11	8	.00	1	ns
35	15	10	11	9	.11	1	ns
36	16	10	11	7	.00	1	ns
37	13	11	9	8	.01	1	ns
38	13	9	9	9	.33	1	ns
39	15	10	10	9	.24	1	ns
40	15	11	8	8	.24	1	ns

TABLE 20

Continued

Sequence	Number of Categories				x^2	df	p
	Undistracted		Distracted				
	uninformed	informed	uninformed	informed			
41	16	11	11	9	.09	1	ns
42	16	10	12	10	.12	1	ns
43	13	9	9	8	.14	1	ns
44	13	10	10	8	.00	1	ns
45	14	8	10	8	.27	1	ns
46	13	10	9	6	.04	1	ns
47	15	9	9	9	.66	1	ns
48	12	14	11	9	.35	1	ns
49	12	8	8	8	.36	1	ns
50	13	10	11	8	.01	1	ns
51	13	6	11	8	.45	1	ns
52	16	12	13	10	.00	1	ns
53	17	8	15	9	3.27	1	ns
54	14	10	12	9	.00	1	ns
55	12	10	6	10	1.07	1	ns
56	11	7	11	10	.33	1	ns
57	13	10	10	8	.00	1	ns
58	16	10	11	8	.06	1	ns
59	14	11	10	10	.16	1	ns
60	17	15	13	8	.40	1	ns

TABLE 20

Continued

Sequence	Number of Categories				x^2	df	p
	Undistracted		Distracted				
	uninformed	informed	uninformed	informed			
61	13	9	9	8	.15	1	ns
62	13	12	10	8	.10	1	ns
63	15	8	10	8	.40	1	ns
64	15	11	11	8	.00	1	ns
65	16	11	11	10	.23	1	ns
66	14	11	12	9	.00	1	ns
67	14	9	9	8	.25	1	ns
68	11	9	10	9	.02	1	ns
69	14	9	10	8	.12	1	ns
70	15	9	13	8	.00	1	ns
71	15	9	11	9	7.48	1	.01
72	14	12	12	9	.05	1	ns
73	13	14	8	12	.30	1	ns
74	14	11	12	12	.17	1	ns
75	13	11	11	11	.08	1	ns
76	15	11	11	11	.28	1	ns
77	16	11	12	12	.44	1	ns
78	17	12	11	11	.37	1	ns
79	12	10	13	13	.09	1	ns
80	16	14	12	12	.05	1	ns

TABLE 20

Continued

Sequence	Number of Categories				x^2	df	p
	Undistracted		Distracted				
	uninformed	informed	uninformed	informed			
81	17	10	11	10	.54	1	ns
82	12	11	12	11	.00	1	ns
83	16	12	10	12	.67	1	ns
84	15	10	11	11	.47	1	ns
85	17	11	14	11	.12	1	ns
86	20	13	16	12	.07	1	ns
87	19	12	16	11	.02	1	ns
88	16	10	9	11	1.24	1	ns
89	15	8	15	12	.48	1	ns
90	13	12	17	11	.41	1	ns
91	15	8	7	13	3.90	1	.05
92	18	12	14	12	.22	1	ns
93	17	12	14	10	.00	1	ns
94	14	10	15	14	.23	1	ns
95	15	12	14	15	.29	1	ns
96	17	12	12	16	1.42	1	ns
97	11	10	11	12	.09	1	ns
98	13	9	9	11	.83	1	ns
99	15	9	10	12	1.34	1	ns
100	15	9	10	14	2.08	1	ns

TABLE 20

Continued

Sequence	Number of Categories				x^2	df	p
	Undistracted		Distracted				
	uninformed	informed	uninformed	informed			
101	17	10	12	12	.87	1	ns
102	15	10	11	11	.47	1	ns
103	13	10	11	10	.07	1	ns
104	16	11	15	10	.00	1	ns
105	18	10	14	12	.61	1	ns
106	11	10	10	12	.30	1	ns
107	17	10	13	11	.40	1	ns
108	17	14	12	12	.13	1	ns
109	14	8	16	11	.10	1	ns
110	16	12	12	11	1.79	1	ns
111	20	12	17	12	.09	1	ns
112	13	11	12	12	.08	1	ns
113	17	11	13	11	.22	1	ns
114	17	12	15	12	.05	1	ns
115	14	9	11	11	.53	1	ns
116	17	11	13	11	.22	1	ns
117	18	12	10	10	.48	1	ns
118	15	8	13	13	1.16	1	ns
119	18	10	13	12	.81	1	ns
120	18	11	13	12	.55	1	ns

TABLE 21

Means and Standard Deviations of Latencies

on Arrow Sequences

Sequence		Condition			
		Undistracted		Distracted	
		uninformed	informed	uninformed	informed
1	MEAN	1.68	1.81	1.77	1.93
	S.D.	.33	.38	.53	.57
2	MEAN	1.71	2.12	1.78	1.82
	S.D.	.31	.56	.71	.28
3	MEAN	1.53	1.90	1.54	1.81
	S.D.	.23	.49	.42	.51
4	MEAN	1.58	1.98	1.60	1.80
	S.D.	.28	.46	.36	.37
5	MEAN	1.58	1.92	1.60	1.97
	S.D.	.40	.58	.26	.46
6	MEAN	1.53	1.81	1.77	1.73
	S.D.	.22	.36	.57	.30
7	MEAN	1.70	1.85	1.86	2.02
	S.D.	.47	.38	.58	.55
8	MEAN	1.60	1.91	1.76	2.04
	S.D.	.29	.38	.62	.46
9	MEAN	1.74	1.68	1.68	1.77
	S.D.	.56	.38	.44	.42
10	MEAN	1.62	1.81	1.77	1.96
	S.D.	.36	.36	.33	.51
11	MEAN	1.74	2.09	1.48	1.81
	S.D.	.39	.45	.28	.44
12	MEAN	1.65	2.06	1.80	1.99
	S.D.	.25	.38	.49	.35
13	MEAN	1.72	1.86	1.67	1.98
	S.D.	.26	.37	.34	.60
14	MEAN	1.74	1.99	1.66	1.90
	S.D.	.36	.52	.65	.61

TABLE 21

CONTINUED

Sequence	Undistracted uninformed	Undistracted informed	Distracted uninformed	Distracted informed
15 MEAN	1.74	2.00	1.66	1.94
S.D.	.48	.45	.47	.72
16 MEAN	1.60	1.80	1.47	2.00
S.D.	.23	.43	.32	.40
17 MEAN	1.66	1.92	1.82	1.97
S.D.	.33	.43	.68	.43
18 MEAN	1.67	1.94	1.48	1.89
S.D.	.30	.42	.00	.45
19 MEAN	2.62	2.55	2.58	2.22
S.D.	1.47	.87	.97	.53
20 MEAN	1.61	2.20	1.62	1.94
S.D.	.31	1.00	.60	.41
21 MEAN	1.57	1.84	1.61	1.87
S.D.	.28	.39	.48	.65
22 MEAN	1.74	2.03	1.76	1.98
S.D.	.32	.62	.45	.30
23 MEAN	1.58	2.07	1.77	1.90
S.D.	.43	.39	.40	.40
24 MEAN	1.66	2.05	1.76	1.96
S.D.	.23	.39	.50	.65
25 MEAN	1.56	1.77	1.52	1.69
S.D.	.34	.42	.28	.32
26 MEAN	1.68	1.81	1.52	1.72
S.D.	.35	.33	.38	.47
27 MEAN	1.71	1.84	1.48	1.67
S.D.	.44	.46	.56	.40
28 MEAN	1.63	1.83	1.43	1.77
S.D.	.39	.40	.35	.45

TABLE 21

CONTINUED

Sequence		Condition			
		Undistracted		Distracted	
		uninformed	informed	uninformed	informed
29	MEAN	1.64	1.92	1.64	1.74
	S.D.	.31	.55	.38	.45
30	MEAN	1.55	1.87	1.59	1.87
	S.D.	.27	.40	.36	.56
31	MEAN	1.60	1.94	1.48	1.81
	S.D.	.29	.47	.40	.38
32	MEAN	1.54	1.98	1.59	1.91
	S.D.	.23	.47	.49	.67
33	MEAN	1.60	1.96	1.66	1.86
	S.D.	.34	.49	.47	.47
34	MEAN	1.61	1.88	1.45	1.72
	S.D.	.33	.46	.30	.46
35	MEAN	1.68	1.98	1.54	1.80
	S.D.	.36	.62	.35	.49
36	MEAN	1.66	2.04	1.63	1.89
	S.D.	.32	.47	.40	.52
37	MEAN	1.61	1.83	1.57	1.75
	S.D.	.29	.54	.33	.39
38	MEAN	1.72	2.13	1.62	1.80
	S.D.	.29	.71	.46	.39
39	MEAN	1.68	2.22	1.68	1.92
	S.D.	.38	1.42	.47	.42
40	MEAN	1.61	1.93	1.61	1.79
	S.D.	.40	.54	.58	.47
41	MEAN	1.68	1.93	1.54	1.91
	S.D.	.54	.55	.37	.59
42	MEAN	1.72	1.85	1.58	1.87
	S.D.	.33	.45	.38	.47

TABLE 21

CONTINUED

Sequence		Condition			
		Undistracted		Distracted	
		uninformed	informed	uninformed	informed
43	MEAN	1.67	2.00	1.56	1.79
	S.D.	.43	.64	.29	.51
44	MEAN	1.55	1.94	1.54	1.87
	S.D.	.25	.47	.34	.48
45	MEAN	1.54	1.89	1.47	1.70
	S.D.	.34	.45	.24	.38
46	MEAN	1.82	1.90	1.96	1.99
	S.D.	.43	.86	.67	.75
47	MEAN	1.58	1.95	1.63	1.89
	S.D.	.30	.52	.38	.59
48	MEAN	1.81	2.13	1.61	2.19
	S.D.	.46	.50	.33	.78
49	MEAN	1.59	1.77	1.50	1.70
	S.D.	.30	.39	.23	.31
50	MEAN	1.89	1.73	1.59	1.84
	S.D.	.70	.34	.31	.63
51	MEAN	1.56	1.82	1.59	1.75
	S.D.	.28	.41	.47	.41
52	MEAN	1.49	1.79	1.49	1.64
	S.D.	.40	.30	.36	.38
53	MEAN	1.72	1.85	1.75	1.79
	S.D.	.40	.51	.60	.44
54	MEAN	1.58	1.93	1.60	2.30
	S.D.	.30	.50	.36	.96
55	MEAN	1.52	1.96	1.52	1.89
	S.D.	.21	.68	.41	.59
56	MEAN	1.70	1.91	1.52	1.95
	S.D.	.40	.53	.30	.44

TABLE 21

CONTINUED

Sequence		Condition			
		Undistracted		Distracted	
		uninformed	informed	uninformed	informed
57	MEAN	1.52	1.80	1.57	1.79
	S.D.	.27	.34	.56	.41
58	MEAN	1.60	1.88	1.51	1.76
	S.D.	.26	.51	.31	.54
59	MEAN	1.80	2.10	1.77	2.10
	S.D.	.50	.45	.43	.65
60	MEAN	1.64	1.91	1.63	1.87
	S.D.	.37	.52	.40	.56
61	MEAN	1.68	1.91	1.58	1.89
	S.D.	.34	.43	.35	.47
62	MEAN	1.69	2.01	1.64	1.90
	S.D.	.35	.61	.34	.60
63	MEAN	1.67	2.05	1.56	1.83
	S.D.	.54	.50	.45	.49
64	MEAN	1.58	1.82	1.58	1.73
	S.D.	.29	.29	.37	.40
65	MEAN	1.65	1.95	1.74	1.90
	S.D.	.28	.47	.63	.41
66	MEAN	1.61	1.93	1.59	1.87
	S.D.	.31	.42	.38	.44
67	MEAN	1.67	1.80	1.58	1.92
	S.D.	.39	.34	.50	.54
68	MEAN	1.80	2.02	1.82	1.84
	S.D.	.53	.45	1.00	.45
69	MEAN	1.48	1.82	1.55	1.62
	S.D.	.24	.60	.39	.72
70	MEAN	1.73	1.96	1.65	1.81
	S.D.	.46	.39	.48	.38

TABLE 21

CONTINUED

Sequence		Condition		
	Undistracted		Distracted	
	uninformed	informed	uninformed	informed
71 MEAN	1.64	1.87	1.67	1.79
S.D.	.32	.45	.49	.38
72 MEAN	1.68	1.97	1.63	1.76
S.D.	.28	.44	.56	.72
73 MEAN	1.90	2.16	2.05	2.74
S.D.	.62	.80	1.10	1.98
74 MEAN	1.71	2.12	1.58	1.93
S.D.	.58	.75	.48	.50
75 MEAN	1.69	2.16	1.76	1.97
S.D.	.42	.76	.85	.47
76 MEAN	1.61	1.95	1.56	1.94
S.D.	.24	.55	.24	.55
77 MEAN	1.55	2.01	1.60	1.79
S.D.	.26	.56	.40	.40
78 MEAN	1.64	1.91	1.60	1.81
S.D.	.31	.43	.40	.44
79 MEAN	1.94	2.06	1.76	1.93
S.D.	.70	.54	.49	.40
80 MEAN	1.58	2.10	1.56	1.80
S.D.	.20	.48	.33	.46
81 MEAN	1.57	2.01	1.58	1.90
S.D.	.30	.48	.42	.45
82 MEAN	1.54	1.86	1.62	1.88
S.D.	.32	.35	.41	.51
83 MEAN	1.51	1.86	1.68	1.79
S.D.	.25	.29	.52	.49
84 MEAN	1.56	1.88	1.65	1.98
S.D.	.27	.34	.62	.65

TABLE 21

CONTINUED

Sequence		Condition			
		Undistracted		Distracted	
		uninformed	informed	uninformed	informed
85	MEAN	1.56	1.86	1.50	1.74
	S.D.	.23	.46	.40	.40
86	MEAN	1.57	1.71	1.59	1.66
	S.D.	.26	.34	.48	.42
87	MEAN	1.60	1.86	1.49	1.92
	S.D.	.43	.52	.31	.53
88	MEAN	1.68	2.06	1.67	1.96
	S.D.	.36	.58	.35	.50
89	MEAN	1.74	1.99	1.62	1.87
	S.D.	.42	.42	.25	.78
90	MEAN	2.34	2.42	2.52	2.74
	S.D.	.87	.74	1.39	1.79
91	MEAN	1.85	2.23	2.13	2.16
	S.D.	.46	.85	.86	.89
92	MEAN	1.60	1.91	1.56	1.77
	S.D.	.30	.45	.41	.47
93	MEAN	1.67	1.99	1.61	1.97
	S.D.	.35	.51	.37	.50
94	MEAN	1.97	2.02	2.16	2.20
	S.D.	.69	.52	1.48	.59
95	MEAN	1.79	1.91	1.57	1.80
	S.D.	.57	.39	.29	.37
96	MEAN	1.73	2.09	1.63	1.94
	S.D.	.36	.62	.45	.50
97	MEAN	1.71	1.88	1.56	1.72
	S.D.	.48	.47	.35	.34
98	MEAN	1.64	1.99	1.68	1.85
	S.D.	.32	.45	.37	.58

TABLE 21

CONTINUED

Sequence		Condition			
		Undistracted		Distracted	
		uninformed	informed	uninformed	informed
99	MEAN	1.53	1.77	1.69	1.79
	S.D.	.34	.33	.54	.50
100	MEAN	1.54	1.81	1.53	1.85
	S.D.	.21	.29	.37	.38
101	MEAN	1.60	1.85	1.68	1.81
	S.D.	.44	.61	.74	.38
102	MEAN	1.65	1.90	1.77	1.91
	S.D.	.39	.34	.39	.47
103	MEAN	1.78	1.94	1.69	1.83
	S.D.	.49	.27	.42	.35
104	MEAN	1.62	2.02	1.64	1.94
	S.D.	.23	.46	.46	.45
105	MEAN	1.67	1.99	1.54	1.87
	S.D.	.34	.49	.58	.47
106	MEAN	1.64	1.94	1.63	1.84
	S.D.	.33	.62	.41	.41
107	MEAN	1.63	1.98	1.62	1.79
	S.D.	.36	.70	.43	.28
108	MEAN	1.74	2.02	1.80	1.89
	S.D.	.44	.58	.46	.41
109	MEAN	1.66	1.82	1.63	1.79
	S.D.	.40	.45	.53	.40
110	MEAN	1.56	1.96	1.67	2.00
	S.D.	.22	.52	.42	.68
111	MEAN	1.44	1.72	1.57	1.66
	S.D.	.26	.41	.43	.42
112	MEAN	1.69	2.04	1.56	1.72
	S.D.	.38	.53	.27	.38

TABLE 21

Continued

Sequence		Condition			
		Undistracted		Distracted	
		uninformed	informed	uninformed	informed
113	MEAN	1.62	1.91	1.65	2.00
	S.D.	.33	.39	.45	.45
114	MEAN	1.76	2.06	1.66	2.01
	S.D.	.38	.62	.42	.53
115	MEAN	1.52	1.87	1.57	1.74
	S.D.	.22	.32	.40	.45
116	MEAN	1.66	1.92	1.54	1.99
	S.D.	.31	.58	.40	.50
117	MEAN	1.85	2.21	1.69	1.75
	S.D.	.52	.76	.56	.41
118	MEAN	1.70	2.03	2.29	2.32
	S.D.	.27	.46	1.20	1.39
119	MEAN	1.69	2.04	1.64	2.07
	S.D.	.38	.63	.38	.60
120	MEAN	1.59	1.90	1.65	1.89
	S.D.	.40	.60	.46	.62

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