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The views, opinions, and findings contained in this report are those of the author and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

Publication of this paper sponsored by Committee on User Information Systems.

Abridgment

Recognition Errors Among Highway Signs

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ABSTRACT

Forced choice recognition errors were examined for tachistoscopic presentations of four sign messages (Stop, Go Right, Go Left, Slow Down) displayed in word versus symbol format. Sign exposure durations were 1, 2, and 3 standard deviations (32, 41, and 49 msec) above the mean exposure duration for chance-level presence or absence detection of a traffic sign in the visual field (24 msec). As exposure duration increased, recognition errors decreased more rapidly for Stop message signs than for other messages. Word versus symbol format differentially influenced reductions in recognition errors for Right, Left, and Slow messages but had little influence on errors on Stop message signs. Several pairs of signs were shown to be reciprocally confused with each other, and Merge Right signs were frequently confused with signs presenting three different action messages. For the signs tested, those that are likely to produce recognition errors resulting in accidents were identified as well as those for which recognition errors are unlikely to produce accidents.

The present research was prompted by two major concerns. One concern was the pragmatic concern of civil engineers interested in effective traffic signing to safely guide traffic flow. The second was the theoretical need to discriminate between (a) the purely perceptual operations performed by the brain in extracting sign information and (b) the mental operations involved in driver actions that occur after the recognition process is completed.

The research was initiated by a focus on the failure of drivers to recognize and properly respond to the symbol legend Stop Ahead standard sign W3-1a

(1). The specific circumstance indicating the urgency to examine these issues involved the intersection of two paved county trunk highways in Buena Vista County, Iowa. The highways cross at right angles in rolling terrain. The north-south route is Stop sign-controlled, and east-west traffic is through traffic. Signing of the intersection is clearly visible to drivers approaching from all four directions. North- and westbound traffic encounter a visual obstruction in the southeast quadrant of the intersection, making it imperative that drivers approaching from the south obey the Stop sign on that leg of the intersection. Soon after new symbol legend Stop Ahead signs were erected to precede the Stop signs, a number of accidents occurred that involved failures of drivers to respect the Stop signs. This unexpected increase in accident frequency prompted the County Highway Engineer to request research to more clearly differentiate the factors that cause such accidents. Reported in this paper is a portion of the data from that research.

EXPERIMENTATION

Introduction

The pragmatic concern that initiated the research focused on potential differences in the effectiveness of the word and symbol versions of the Stop Ahead advance warning sign. However, considerations of proper experimental designs dictated that a larger sample of signs be studied, and the set of 16 signs shown in Figure 1 were selected.

Three laboratory experiments were conducted. Experiment 1 tested the effects of these signs on drivers' detection of sign presence or absence in the visual field when tachistoscopic exposures of the signs reduced overall detection performance to chance level. Experiment 2 increased exposure durations above detection level and investigated sign recognition errors as time for the recognition process increased. Experiment 3 measured the time required for deciding what driver action was appropriate for each sign. Reported in this paper is a portion of the data from the second experiment and an interpretation of the recognition error patterns for traffic engineering purposes.

Procedure

The intent of the experiment was to determine whether or not the 16 test signs produced differences in the perceptual operations that extract sign information and generate conscious recognition of the signs. Respondents who participated in the experiment were 36 volunteers from undergraduate courses, faculty, or administrative staff at Iowa State University. All respondents were licensed drivers. Tests of visual acuity were not conducted because (a) the authors' concern was to obtain a representative sample of Iowa drivers rather than a sample of drivers with 20/20 visual acuity, and (b) the experimental design and testing equipment made differences in visual acuity an irrelevant consideration. Age of respondents was not asked because a measure of driving experience was obtained (and found not to be a significant influence on performance in any of our analyses).

The general procedure was to tachistoscopically present two road signs to the subject and then have the subject decide which of the two (the just-presented sign and another sign) shown outside the tachistoscope in clear vision was the sign presented on that trial. Each trial began with the subject viewing a mask and slide consisting of randomly assembled pieces of traffic signs, and the sign presentation was essentially an interruption of the subject's viewing of the mask. The experiment required 240 trials for each subject. This permitted 15 test trials for each sign. The performance measure was the number of error choices, of a possible 15, that each subject made for each sign.

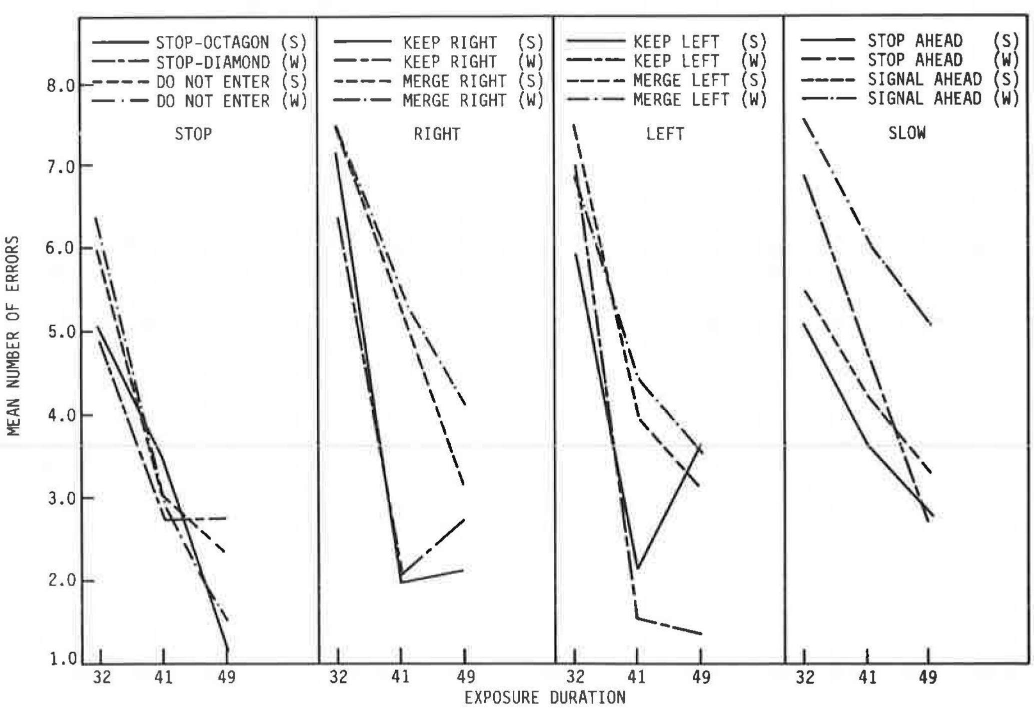

FIGURE 1 Sign recognition errors.

The 36 subjects were assigned to three groups of 12 subjects each, and exposure durations differed for the three groups. Exposure durations were based on the results of the detection experiment (Experiment 1). For Groups 1, 2, and 3, exposure durations were 32, 41, and 49 msec, respectively. These durations were, respectively, 1, 2, and 3 standard deviations above the mean exposure duration for chance-level presence or absence detection in Experiment 1 (24 msec). This manipulation permitted evaluation of the influence of sign message (Stop, Go Left, Go Right, Slow Down) and format (word versus symbol) on reducing recognition errors as time for completion of the recognition process increased.

RESULTS AND DISCUSSION

Most simply stated, the results of this experiment showed that the perceptual operations performed in recognizing highway signs differ considerably among signs. The message presented by the sign, the symbol versus word format of the sign, and exposure duration all interacted in determining number of recognition errors. This complex interaction is summarized graphically in Figure 2. However, findings of pragmatic concern were clear in the data.

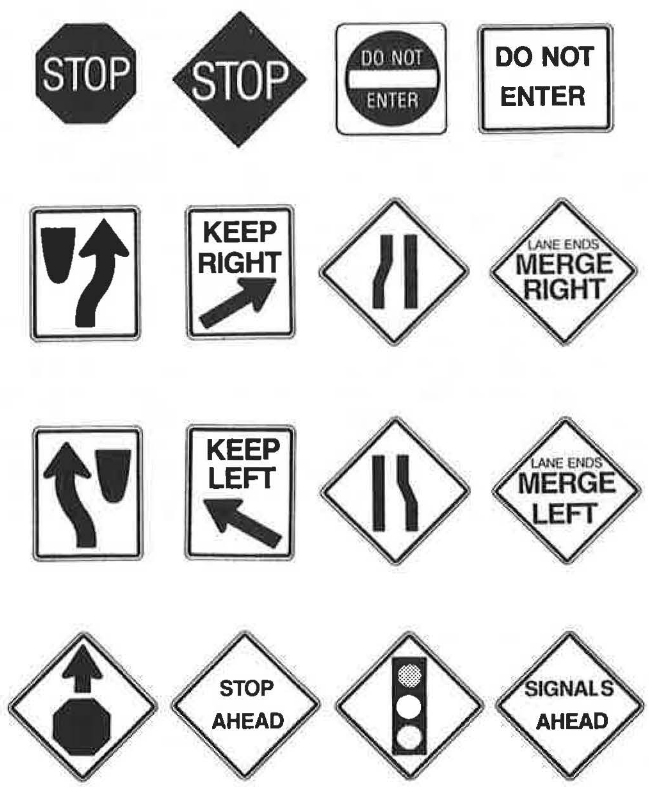

FIGURE 2 Matrix of signs for detection, recognition, and reaction experiments.

As expected, the number of recognition errors decreased as exposure duration increased, and most of the reduction in errors occurred as exposure duration increased from 32 to 41 msec; further reduction in errors when exposure duration increased from 41 to 49 msec was not significant. The important implication here is that the perceptual operations of sign recognition are completed rapidly, and the action decision triggered by those perceptual operations occurs in a time period that is likely to be less than 50 msec. A second finding of practical interest was that fewer recognition errors were made for signs that instruct a driver to stop than for signs that instruct a driver to go right, go left, or slow down. This result conformed to the result from Experiment 1, reported elsewhere (2), showing that even when overall presence or absence detection performance was at chance level, Stop message signs were detected more accurately than were signs instructing a driver to go right, go left, or slow down.

These findings are, in general, evident in the data presented in Figure 2. Inspection of Figure 2 also reveals informative differences in the patterns of error reductions for Stop, Go Right, Go Left, and Slow Down sign messages. For Stop action message signs, errors declined in about the same fashion for Stop and Do Not Enter signs whether they were symbol or word format signs. For Go Right action and Go Left action signs, similar patterns of error reduction were evident. As exposure duration increased, the number of recognition errors decreased more rapidly for Keep Right (or Left) signs than for Merge Right (or Left) signs, and there was little difference between word and symbol signs. For Stop Ahead signs, fewer errors were made for symbol signs than for word signs when the exposure duration was 32 msec but, when exposure duration was increased to 49 msec, the number of errors for both word and symbol signs had reduced to about the same level. The implication is that the symbol version of the Stop Ahead sign can be more readily recognized if viewing time is extremely limited, but if sufficient viewing time is available, both word and symbol Stop Ahead signs can be recognized equally well. For Signal Ahead signs, fewer recognition errors were made for symbol signs at all three exposure durations.

The authors examined these data more closely to determine the types of confusions among signs that occur during perceptual analysis of the various signs. For the three groups of 12 subjects who were tested with 32-, 41-, and 49-msec presentations, the authors calculated the mean number of subjects who incorrectly chose, for each presented sign, each of the other 15 signs in recognition errors. A 99 percent confidence interval about each of those means was then calculated. Signs for which the number of subjects making recognition errors exceeded that confidence interval were identified as signs producing either significantly larger or significantly smaller than average numbers of errors.

Table 1 summarizes the evidence for significantly high numbers of errors. The extreme left column identifies the 16 signs presented for identification. The column headings of the table identify, for the 32-, 41-, and 49-msec test exposures, the message of the sign that was given in the error response. The numbers presented in the body of the table identify the specific sign that was given in an incorrect response.

At least three kinds of important information can be extracted from Table 1. First, one can identify the signs for which confusions were reciprocal--that is, signs that were confused with each other irrespective of which sign was the presented test sign and which sign was the error choice. For 32-msec test presentations, the following signs were reciprocally confused:

Stop Ahead (word)--Do Not Enter (word)
Stop Ahead (word)--Keep Left (word + symbol)
Merge Right (word)--Do Not Enter (word + symbol)
Merge Right (word)--Merge Right (symbol)

TABLE 1 Sign Pairs Producing High Error Rates

	Error Choice Message											
	32 msec				41 msec				49 msec			
Sign No.	Stop	Right	Left	Slow	Stop	Right	Left	Slow	Stop	Right	Left	Slow
1	2				2				2			15
2		9	8,11			5	12					
3	1			13		6						
4	2	9							2			
5	1,2		12	16						6		
6	2	10	7	14,16							12	
9	1,3,4	6	11	13	1,3	5,6	7,11	13,16	1	6	11	13
10	2	10	8	14,16	4		8,12	14		10		14
7	2	10		13								
8										5,6,9		13
11	4	10	8	13	3,4	9		13		9	7,8	13,16
12	3	19	7	13,15,16		10	7,8		2			13,14
13	3,4	5,6	7,8	14		6,9	7,8	15,16	1	6,9	11	
14							7		4		7,8,11	
15	2,3,4		11	13,14,16	2,3	6,9	7,8	13,14,16	3,4	6,9	8	13,14,16
16	4					10	8,12					13,14

When test exposures were 41 msec, the following signs were reciprocally confused.

Merge Right (word)--Merge Left (word)
Merge Right (symbol)--Merge Left (symbol)
Stop Ahead (word)--Merge Right (word)
Stop Ahead (word)--Signal Ahead (word)

When test exposures were 49 msec, the following signs were reciprocally confused.

Merge Right (word)--Merge Left (word)
Stop Ahead (word)--Merge Right (word)
Stop Ahead (word)--Merge Left (word)

The next important problems that these findings address are determination of (a) which recognition errors are likely to produce incorrect driver actions and (b) which ones are not likely to be dangerous. This is determined in part by the reciprocal confusions between pairs of signs noted earlier. The Left-Right message signs provide a particularly useful example. For all three test exposures, signs that instruct a driver to either Merge or Keep Right or Left were reciprocally confused with each other, and the confusions occurred with both the word and symbol legend signs. In fact, the reciprocal confusions appear to identify Merge Right signs as particularly troublesome. Drivers appear to have particular difficulty in recognizing these signs; Merge Right signs were involved in 7 of the 11 reciprocally confusing sign pairs noted above, and they were reciprocally confused with 5 different signs among which three different messages were presented. It is also important to notice that confusions involving Left-Right messages were not much affected by viewing time.

Some of the other signs were also frequently given in error responses, but these error choices are unlikely to produce dangerous driver actions. For example, the standard octagonal Stop sign (MUTCD R1-1) was given in a number of error responses, but those responses were to other signs that instruct a driver to stop. These errors may indicate that even when the driver is uncertain about which of several possible signs was shown, enough sign information has been extracted to communicate the Stop message, and the driver chooses the sign that presents that message most clearly.

The format of Table 2 duplicates that of Table 1 but summarizes the evidence on signs that prompted significantly lower than average numbers of error choices. These data indicate that Stop message signs were least frequently confused with signs presenting other action messages; the next-least-frequently confused signs were those that instruct a driver to

TABLE 2 Sign Pairs Producing Low Error Rates

	Error Choice Message											
	32 msec				41 msec				49 msec			
Sign No.	Stop	Right	Left	Slow	Stop	Right	Left	Slow	Stop	Right	Left	Slow
1	4	5,6,9	8,11,12	14,16	3,4	5	7,11					
2	1	6,10	7	14,15,16		9	7,11			5,10	8,12	13,15,16
3		10		15	1,4	9,10		13,15,16	4	5,10		16
4	1		7,12		3		8,10	11	3			
5	4	9	11	14	1,3,4	9,10	11	15		10		15
6	3	5			1,2,3,4	10		14,15,16			11	16
9							12					
10						5		13		9		
7				16	1,2	6,8	9,10	13,14,15,16			11,12	13
8	3,4		12	15	2,4	5,9	11	13,15,16				
11				16		5						
12	2		11		2,3							
13			12	15	1,2					10		15
14	1	5,9	8,12	15	3,4	5						
15	1	6										
16			7,11,12	13								

slow down and be cautious. The least frequently given error choices were the Signal Ahead symbol sign (MUTCD W3-3), the Signal Ahead word sign (MUTCD W3-3a), and the Merge Left word sign (MUTCD W9-2).

CONCLUSIONS

Based on these data, the authors have concluded that

1. Driver errors in recognizing signs once a sign is detected in the visual field are lower for signs that require a stop action by the driver than those that require a driver to either slow down or move laterally. This finding implies that failures to respond to Stop message signs are likely due to factors other than perceptual operations.
2. Errors in recognizing signs decrease sharply with very small increases above threshold presence or absence detection exposure durations. Errors in perceptual recognition operations are likely to occur within the first 50 msec of viewing time after which recognition errors tend to level off.
3. The formats of some signs tend to produce many recognition errors with other sign messages (Merge Right) whereas other signs infrequently occur in recognition errors (Signal Ahead).

ACKNOWLEDGMENT

The authors gratefully acknowledge the support of the Iowa Department of Transportation Highway Division through Iowa Highway Research Board Project HR-256, from which the data presented in this paper were taken. The support of both the Engineering Research Institute and the Sciences and Humanities Research Institute are also acknowledged.

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The opinions, findings, and conclusions expressed in this paper are solely those of the authors.

Publication of this paper sponsored by Committee on User Information Systems.

Abridgment

Restraint Usage at Child Care Centers

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ABSTRACT

A pilot project was conducted by the University of Alabama to study child restraint usage at two child care centers. Rewards were used to encourage parents to transport their children in approved safety devices, and the usage characteristics were examined. A traditional ABA study (baseline--intervention--return-to-baseline) indicated that usage increased from 48 to 72 percent at one center, and from 11 to 54 percent at the other center. These results soundly demonstrated that psychological learning theory was extremely effective in increasing safety seat usage. A major thrust of the project was the study of pertinent characteristics of parents and children. Age, sex, arrival time, vehicle type, and place in vehicle were found to influence restraint use. Overall, the pilot study provided a sound beginning for an intensive program to increase child restraint usage.