Effect of Sign Position and Brightness on Seeing Simulated Highway Signs

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Simulated "interstate green" signs of varying brightnesses were shown to subjects against typical highway backgrounds. Subjects were asked to indicate which signs they could see best under the various conditions depicted, and were simultaneously required to engage in an auxiliary task involving fixation upon small red lights at road level. Experiments performed were designed to study the variables of sign position and brightness in relation to ease of seeing signs under simulated highway conditions.

•A PREVIOUS paper (1) described the program of research on highway traffic sign requirements, the first phase of which was an annotated bibliography (2) of pertinent research reports for the preceding 10 years. Another paper (3) described a general experimental procedure employing a secondary or auxiliary task to load the subject and assure visual fixation at road level on a projected highway scene. The primary task consisted of indicating which of 4 simulated signs flashed on the screen at intervals were seen first and best. The auxiliary task was to relight a number of small red lights which went out in random order from a matrix of 12 lights located just below the highway pictured on the screen. The present report gives the results of the first 5 experiments undertaken using this general experimental procedure.

The general objective of this research was to measure the effects of various highway sign characteristics on attention value and actual seeing of the sign when viewed on the highway against various backgrounds. The aim was to control as many variables as possible in a laboratory setup so as to measure the probability of a sign being seen. It was not the purpose to measure the distance at which a sign first becomes legible, but rather whether it is more likely or less likely to be seen among other signs and background objects when suddenly exposed to view in traffic situations such as emerging from behind a large truck, coming over a hill, or rounding a curve.

RESEARCH PROGRAM

The laboratory simulation procedure involved colored scenes projected on a screen in front of a subject, who sat with a series of four buttons under his right hand and responded to simulated signs flashed on the background highway scene. He indicated the location of the sign seen first and best by pushing the appropriate button, and similarly indicated those seen second, third, and fourth.

An auxiliary task consisted of relighting from 1 to 4 small red signal lights in a matrix of 12 by pushing 1 of 4 buttons under the left hand corresponding to the number of lights extinguished. Automatic control circuits randomly varied the number of lights turned off and the subject's own response paced the task.

Subjects were male and female college students. Prior to experimental participation they were questioned on driving experience, age, color blindness, and knowledge

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of procedure used. In a very few cases the subject adopted a procedure which indicated that he had misunderstood the instructions; these cases were eliminated before data analysis was begun.

The instructions were to respond to signs as if the subject were driving on a highway, and to continue relighting the small signal lights whenever they went out. When a set of simulated signs was exposed, the subject was to indicate by pushing the appropriate buttons which of the signs he saw first and best, which second, etc. In each case the subject was given a period of practice in order to become acquainted with the experimental set-up and the operation of the buttons.

Visual adaptation was obtained by projecting the next background to be used during the practice period and preceding each series. Due to the auxiliary task, visual fixation was on the road at the instant each sign combination was actuated. Actuation of the next sign presentation occurred after 2 or more light signal responses, and was triggered by one of the left-hand responses in random order. The background scenes were selected from color photos taken on the highway for this particular purpose. The attempt was to obtain representative scenes with relatively even brightness of background in order to control that factor. Simulated signs of a color approximating interstate green were photographed overlaying the background scenes in order to produce the stimulus slides. Brightness of the different simulated signs was varied by using different density neutral filter layers of the same photographic material as the signs and superimposed on the basic color. Four degrees of brightness were chosen to obtain a practical range for experimental use (see Appendix).

Figure 1 shows the subject's view of the simulated signs and the location of the red signal light matrix in the foreground. Figure 2 shows the 2 sets of response buttons and the control and recording equipment. with the dual tachistoscope panel and shutters at the upper right.

Two types of scoring were used—the number of first responses for each sign brightness and position, and the number of subjects giving a predominant first response for

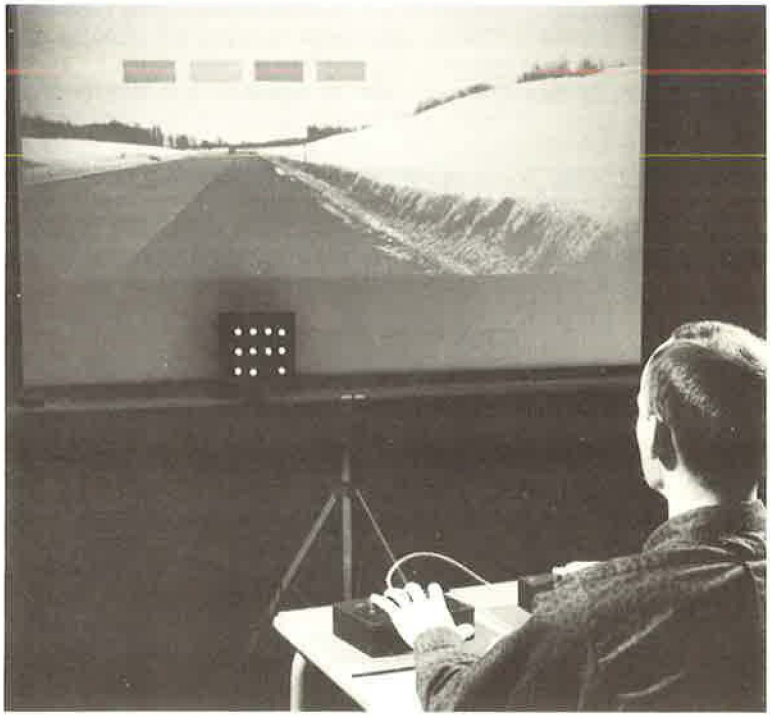

Figure 1. Highway scene with simulated signs and signal lights of auxiliary task.

a given stimulus combination. The "first seen" responses to each sign were expressed as percentages of each subject's responses to a given series of slides (24 unless some were omitted). The total "first" responses to each sign were added for the group of subjects and expressed as a percentage of the total response of the group. That is, for Subject A

	Sign 1	Sign 2	Sign 3	Sign 4
	f_1	f_2	f_3	f_4
Percent "seen first"	$\frac{f_1}{\Sigma f}$	$\frac{f_2}{\Sigma f}$	$\frac{f_3}{\Sigma f}$	$\frac{f_4}{\Sigma f}$

where Σf = 22-24. For Group A . . . N

$$\text{Percent "seen first"} \quad \frac{\sum_{A}^{N} f_1}{\sum_{A}^{N} \Sigma f} \quad \ldots\ldots\ldots\ldots\ldots\ldots$$

Analysis of variance, the median test or the sign test was used, depending on the type of data, to test whether differences were greater than expected by chance. Difference presentation orders were analyzed separately first and then combined where

Figure 2. Response buttons, control, recording equipment and dual tachistoscope (upper right).

differences between the groups were not significant. Data were also tabled, charted, and plotted to show the relationships exhibited.

Effects of Sign Position and Brightness

The purpose of Experiment 1 was to check for effect of sign position and to measure effects of sign brightness against background without letter effects. Blank simulated signs of 4 brightnesses were located 2 over and one on each side of the highway in one series, and all 4 over the highway in another series. Both day-snow and night backgrounds were used. Groups of 10, 11, 10 and 12 subjects each saw the signs against a different background.

Analysis of the first choices showed that signs in positions over the highway were seen first relatively more frequently than those beside the highway. This was true when effects of relative brightness of the simulated signs were equalized. Table 1 shows that the differences between sign positions were significantly greater than chance. In addition, with position balanced out, the brighter signs were seen more frequently against the night background and the darker signs against the day background (Fig. 3).

Because signs over the highway were seen first more frequently, this position had an advantage in the laboratory setup. This might occur partly from the controlled situation using eye movements starting from the signal light matrix in the foreground. Position preference on an actual highway might or might not be similar, depending on illumination and other conditions. For valid comparisons in the laboratory situation, however, it was decided to use only the "over the highway" position in future experiments. Results would be applicable to side-positioned signs if background and other variables were the same.

Experiment 5 was run later to check the effect of blank sign brightness seen against two other backgrounds used in Experiments 2 and 3. In this experiment a group of 10

TABLE 1

EFFECT OF LOCATION OF SIMULATED SIGNS RELATIVE TO ROADWAY[a]

Item	Day				Night			
	df	SS	MS	F	df	SS	MS	F
(a) Overhead Only								
Signs	3	1,858	619.3	9.8[b]	3	2,117.8	706	34.44[b]
Position	3	93	31	0.5	3	150.9	50.3	2.45
S × P	9	24	2.67	0.037	9	102.7	11.4	0.56
Within	144	9,084	63.1		144	2,958.9	20.5	
	159	11,059			159	5,330.3		
(b) Overhead and Side								
Signs	3	4,781.5	1,593.8	41.6[b]	3	3,006.3	1,002.1	50.4[b]
Position	3	410.3	136.8	3.57[c]	3	1,022.4	340.8	17.1[b]
S × P	9	151.5	16.8	0.44	9	58.0	6.4	0.32
Within	160	6,126.2	38.3		112	2,223.4	19.9	
	175	11,469.5			127	6,310.1		

[a]Analysis of variance of frequency signs were seen first—4 brightnesses, 4 positions.
[b]Significant at $P < 0.001$.
[c]Significant at $P < 0.05$.

subjects saw day-hill and the second night background with blank signs followed by day-snow with blank signs. A second group of 12 subjects was shown the same slides in reverse order to balance out possible order effects. The results were similar to the overhead presentation results from Experiment 1 and confirm Experiment 1 for the second night backgrounds and the day-hill, which had not previously been used with blank signs. Figure 3 shows the results of Experiments 1 and 5.

Effects of Relative Sign and Letter Brightness

The purposes of Experiment 2 were to check the results of Experiment 1 and to measure the effect of lettered signs against several backgrounds. Simulated signs of the 4 brightnesses were used with 5 white nonsense letters on each sign. Backgrounds employed were day-snow, day-hill (a dark hill below a bright day sky, with signs projected against the hill), and 2 twilight scenes which had been made by reduced exposure of the day-snow slide. The reduced exposure had the effect of producing darker and darker scenes in which the signs as well as the highway and background all were reduced in brightness. Also used in Experiment 2 were the same blank signs against a night background as had been shown to the subjects in Experiment 1. This was done in order to relate the results of the 2 experiments.

Two groups of 16 subjects (a total of 32) each saw the signs against all 5 backgrounds. Group 1 saw them in the order of night, twilight, day-snow, and day-hill; Group 2 was shown the same slides in reverse order. The backgrounds used in the practice series were half day and half night (12 each). In order to adapt vision to the next following series, the practice series was ended with night for Group 1 and with day for Group 2.

Results against the night and day-snow backgrounds were similar to those in Experiment 1, i.e., the brightest signs were seen first most frequently against night and

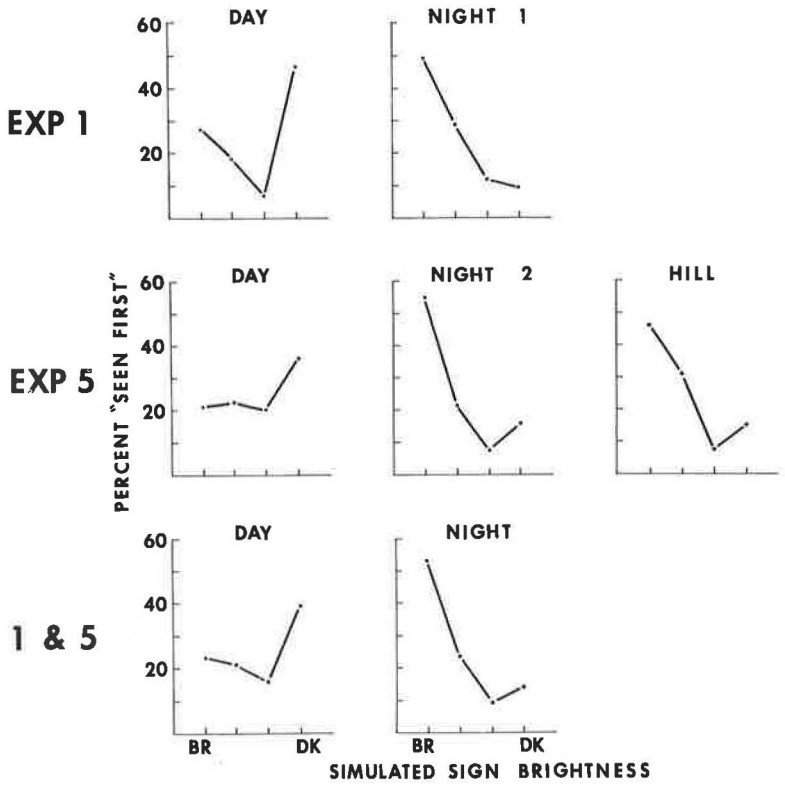

Figure 3. Effect of relative brightness of blank simulated signs.

the darker signs against the day background. The 2 simulated twilight scenes gave results similar to that of day-snow. Against the day-hill background, however, the second brightest sign was seen first most frequently. This was the most saturated green used, the brightest sign being somewhat desaturated by a white translucent layer. Figure 4 shows the results of Experiment 2.

Experiment 3 involved further measurements to check the results of Experiment 2, especially for the day-hill background. In addition, this experiment was designed to check the similarity of patterns for the 2 twilight backgrounds and for lettered signs against a night background. The same lettered signs were used as in Experiment 2, plus a lettered sign against an improved night background (night 2). The same day-snow, day-hill, and darker of the 2 twilight backgrounds were employed. There was also an additional intermediate background using the dark twilight scene but with signs at full brightness. This last series of presentation slides was made by placing the simulated signs on a print of the dark twilight background and then photographing with full lighting. This had the effect of maintaining the dark background, with the higher brightness of the signs comparable to that in the day-snow series.

Two groups of 13 subjects (total of 26) each saw the complete series of backgrounds, again with orders reversed. Care was taken to adapt vision for the next series by allowing several minutes between series with the new background on the screen. The results of the experiment (Fig. 5) were generally similar to those of Experiment 2 for night and day patterns. However, one group saw the bright signs first more frequently against day-snow and twilight backgrounds than did the other group. The differences between the 2 groups were tested for significance by separately scoring each individual as to his predominant response; i.e., if he saw Sign 1 the largest proportion of times, he was scored as predominately seeing this sign even though he also reported Signs 2, 3, and 4 a few times. The frequencies for the 2 groups were then examined by means

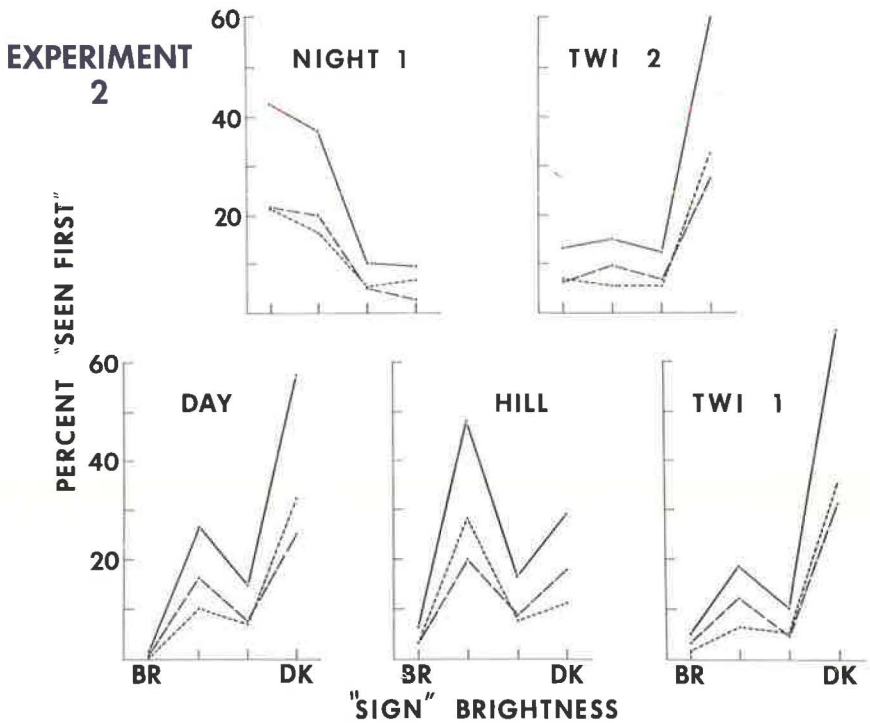

Figure 4. Effect of relative sign and letter brightness: dotted line = Group 1, dashed line = Group 2, and solid line = total group response.

of a contingency chi-squared test, which showed that the groups differed significantly only for the day-snow and dark twilight backgrounds, and that there were no significant differences in the rest of the results. The higher percentages for Sign 2 were similar to a hump in the curves for Experiment 2.

Thus, Experiment 3 indicated that some subjects may respond first more frequently to bright signs against day-snow, darker twilight, and intermediate backgrounds. The brightest 2 signs were consistently seen first most frequently against the night 2 and day-hill backgrounds.

Results from Experiments 2 and 3 were then combined (Fig. 6). They showed that the 2 highest brightness signs were seen first most frequently against day-hill and night backgrounds, with the second brightest (most saturated color) being seen slightly better than the brightest against the day-hill scene. First responses to the dark twilight, day-snow, and intermediate backgrounds in Experiment 3 showed a puzzling hump or else a double-ended characteristic in percentage of "seen first" responses. One pattern corresponded to the results of Experiments 1 and 5, where the darkest sign was seen first most frequently against day-snow. A reverse response by some subjects, however, was responsible for the hump in the curves (Figs. 4 and 5). This was more the pattern for the night and day-hill backgrounds.

Effect of Instructions

Experiment 4 was designed to test whether instructions had unintentionally introduced the idea that responses to different background series should be the same. This experiment was run because during Experiments 2 and 3 the possibility had arisen that some subjects might be developing a habit of responding to the first series viewed which

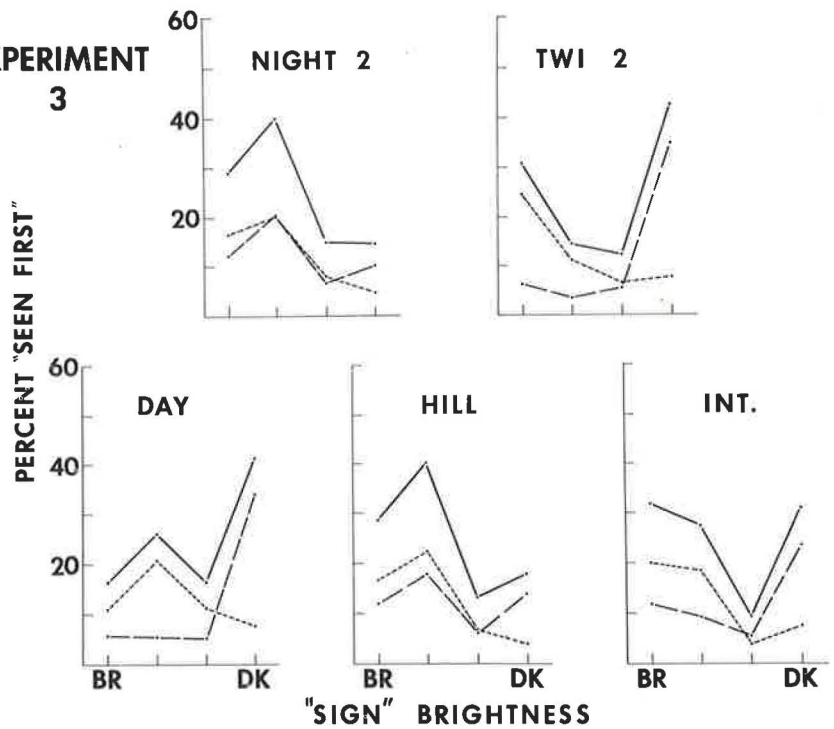

Figure 5. Effect of relative sign and letter brightness: dotted line = Group 1, dashed line = Group 2, and solid line = total group response.

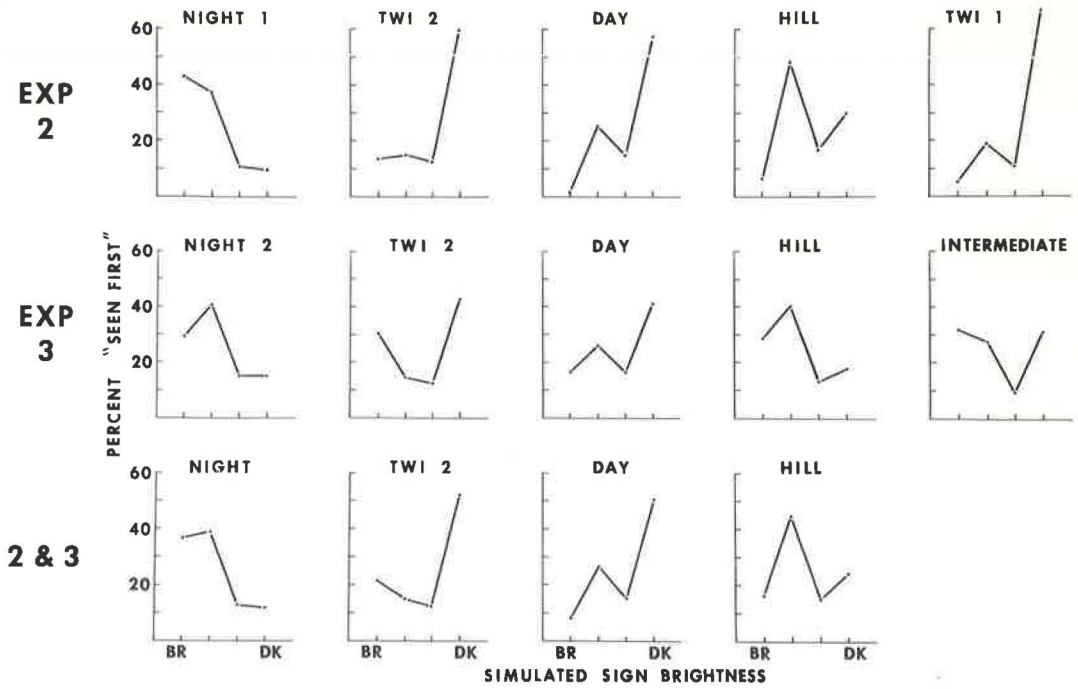

Figure 6. Combined effects of relative sign and letter brightness.

influenced later series. In the experiment, 13 subjects were shown the same backgrounds as those shown in Experiment 3 (day to night order), but instructions were modified to stress the possibility that different presentation series might be seen differently. The results show a reversal of the night pattern which had been consistent in the other experiments. It was concluded, therefore, that the subjects had been influenced to analyze the presentations afterward rather than to respond with their first reactions. These responses as a result were probably not as closely related to those on the road as the responses to the original instructions had been.

CONCLUSIONS

From the entire group of experiments, it can be concluded that the signs highest in brightness were seen first most frequently against night backgrounds. The lower brightness signs were seen first most frequently against the day-snow background, but some subjects saw the high brightness signs first against these backgrounds also. Against the hill in the day-hill background the brighter signs showed an advantage.

There were 2 types of responses to the relative sign brightnesses with day backgrounds, represented by a knee or U shape in the curves. This may represent 2 characteristic responses for different people, i.e., 2 "population stereotype" responses. On the other hand, the same people may respond sometimes one way and sometimes the other; in certain cases the responses were of both types for the same person. This double response may indicate 2 factors, one or the other of which may dominate the response of the subject at a given moment. In the case of the intermediate background these 2 appeared to be equally frequent. The factors of letter-to-sign and sign-to-background brightness may affect these 2 opposite response patterns. This question is being investigated further, along with the general question of the effect of letter brightness and letter-to-sign brightness ratio.

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Appendix

AVERAGE BRIGHTNESS (FOOTLAMBERTS) OF SIMULATED SIGNS, LETTERS, AND BACKGROUNDS

Object	Day-Snow	Twilight I	Twilight II	Intermediate	Day-Hill	Night 2
Sign 1	1.70	0.53	0.15	1.79	2.04	2.34
2	1.14	0.32	0.12	1.13	1.15	1.14
3	0.97	0.25	0.09	0.99	1.06	1.00
4	0.70	0.17	0.06	0.64	0.68	0.64
Background	2.31	0.63	0.16	0.75	Sky 2.70	0.09
Letters	6.55	3.34	1.54	6.59	Hill 0.19	7.34
					7.14	

BRIGHTNESS RATIOS: SIGN/BACKGROUND AND LETTER/SIGN

Object	Day-Snow	Twilight I	Twilight II	Intermediate	Day-Hill	Night 2
Sign/Background						
Sign 1	0.74	0.84	0.94	2.39	1.52	24.89
2	0.49	0.51	0.75	1.51	0.86	12.13
3	0.42	0.40	0.56	1.32	0.79	10.61
4	0.30	0.27	0.35	0.85	0.51	6.81
Letter/Sign						
Sign 1	3.80	6.30	10.27	3.68	3.50	3.14
2	5.74	10.44	12.83	5.83	6.21	6.44
3	6.75	13.36	17.30	6.66	6.73	7.36
4	9.36	19.65	27.50	10.30	10.50	11.47