

Letter and Sign Contrast, Brightness, and Size Effects on Visibility

T. W. FORBES, J. P. FRY, JR., R. P. JOYCE, and R. F. PAIN
Division of Engineering Research and Department of Psychology,
Michigan State University

•AN earlier report (1) provided results of experiments on sign position and brightness variables, and was preceded by an annotated bibliography (2), and a paper describing the research program (3). This paper deals with experimental results on sign size and brightness and letter-to-sign brightness ratio.

The experimental procedure was the same one used earlier. A typical highway scene for day or night conditions was projected continuously on the screen in front of the subject. From time to time under automatic control, keyed by his own responses to an auxiliary task, four simulated "interstate green" highway signs were flashed on the screen superposed on the previous highway scene. Thus visual adaptation was maintained constant. The auxiliary task was to relight one to four small red lights which went out in random order from a matrix of 12 lights located just below the highway picture on the screen.

This report gives the results of four additional experiments which used this same general experimental procedure. The objective of this series of experiments was to measure (a) the effects of sign size, brightness, and letter-to-sign brightness ratio, and (b) the effects of competing signs on highway sign visibility. The laboratory approach enabled the use of many combinations and better control of conditions than would be possible in outdoor, full-scale experiments. No attempt was made to measure legibility of the legend, but a combination of letters and symbols gave an indication of the effect of the letter-to-sign brightness ratio.

The purpose of Experiment 6 in the series was to investigate size and brightness combinations with the brightness of the letters and symbols held constant. To explain effects found in Experiment 6, Experiment 7 used blank simulated interstate green signs (of the same size and brightness combinations but without letters or symbols). Experiment 8 further investigated effects of letter brightness with the same simulated sign brightness and size combinations but with the letter-to-sign brightness ratio maintained more nearly constant. Experiment 10 employed signs of one size only, viewed against a night background to measure the effect of competing advertising signs.

RESEARCH PROGRAM

The laboratory simulation procedure was the same as that used in the five experiments previously reported. A highway scene in color was projected on a screen in front of the subject, who responded to simulated signs flashed on the same background for 1-second intervals. The subject indicated which of the four signs was seen "first and best" by pushing the appropriate button under his right hand and also the one seen next best.

An auxiliary task consisted of relighting one, two, three, or four small red signal lights in a matrix of 12 by pushing the appropriately numbered button under his left hand. Automatically controlled circuits randomized the number of lights turned off. At unpredictable intervals, the subject's response activated the next stimulus sign combination presented. The setup was illustrated in Figures 1 and 2 of the earlier report (1).

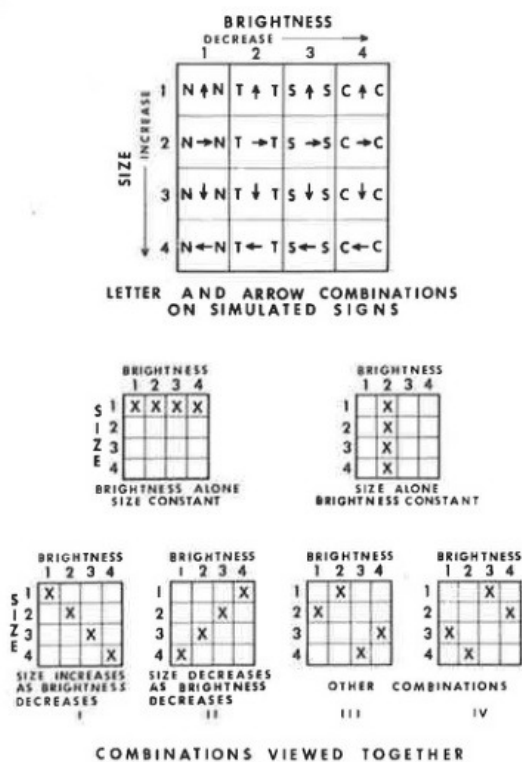


Figure 1. Size and brightness stimulus combinations.

ferences was tested statistically by use of the sign test, or the "t" test of mean differences.

Effects of Size and Brightness With Constant Letter Brightness

Experiment 6 was designed to measure the combined effects of brightness and size on sign visibility. The experimental design used the same four brightnesses used previously and a series of four sign sizes, the smallest being that used in previous experiments. Balancing out the effect of different sign positions, brightnesses, and sizes was necessary for a good experimental design. However, all possible combinations would have required 578 stimulus slides which probably would have introduced fatigue effects. As a compromise, a series of 24 presentations each for day and for night series was developed to give a total of 48 stimulus slides. Each simulated sign carried an arrow and two capital letters designed to be well within legibility range, since it was not desired to measure legibility. Figure 1 shows the letters and arrow directions used, one of the four letters for each brightness, and one of the four arrow directions for each size of sign.

A total of 46 subjects viewed the signs. Half saw the randomized series of slides against the day-snow and the other half against a night background. The 24 stimulus slides included four different orders of the following: (a) four brightnesses of the same size sign, (b) four sizes of the same brightness sign, (c) one diagonal in which size and brightness increased together, (d) one diagonal in which one increased and the other decreased, and (e) a folded diagonal so as to include all combinations in one of the series.

The subjects were instructed to ignore the particular letters and arrows and to record their immediate reaction as to which of the four signs was "seen best and quickest." They were then given practice with the auxiliary task and finally with a practice series of the simulated slides. There were 50 practice trails with the relighting task and a series of 24 practice slide presentations.

Subjects were given practice with the auxiliary task and also with a partial series of simulated sign combinations. They were instructed to continue relighting the small signal lights and, when a set of simulated signs appeared, to give their immediate reaction as to which sign was "seen first and best" and which next best. Each group of subjects saw the test signs against only night or only day highway backgrounds. This eliminated the possibility that having seen an earlier series against a different background might influence the subject's responses.

A darkened laboratory was used for the experimental work. The practice period furnished over five minutes of visual adaptation to the particular highway scene. This adaptation was maintained constant by continuous projection of the background scene alone when the simulated signs were not showing. In making the colored stimulus slides, the plain background always was made at the same time and under the same conditions as the stimulus slides carrying the simulated signs.

The number of first responses to each of the simulated sign combinations was scored from the paper tape of a multipen recorder actuated by the subject, and summated for each group of subjects. Significance of dif-

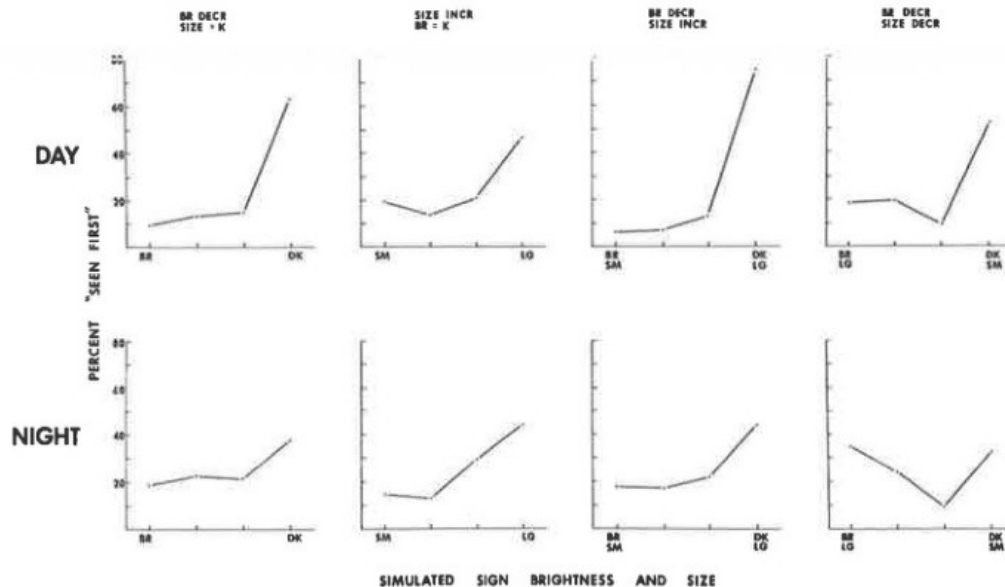


Figure 2. Results of Experiment 6—bright letters and arrows.

Scoring of the paper tape record from the multipen recorder showed which of the four simulated slides in each presentation was indicated by the subject to be seen best. The record for each subject was scored and tabulated. The sum of the scores for each of the possible combinations was entered in one box of the matrix.

These scores were then summated for each of the combinations of four brightnesses, sizes, or diagonals. Analysis could not be carried out across all combinations because every size and brightness was not seen in combination with every other.

Results are shown in Figure 2. The upper row of figures shows that, against the day-snow background, the darkest and the largest signs were seen best with the other variable held constant. When brightness decreased as size increased, darkest and largest signs were seen best. When size and brightness decreased together, dark-and-small signs were seen best more frequently than bright-and-large. Against the night background, somewhat similar relationships occurred, except that there was less additive effect of dark-and-large together and a larger percent of bright-large and dark-small being seen best.

The day relationships were similar to those found in earlier experiments. However, the night results showed the expected advantage of the largest sign, but an unexpected advantage of the darkest sign. This was contrary to results in the earlier experiments in which the brightest sign was seen best against night backgrounds.

It was hypothesized that the bright letters and the arrow symbol on each sign had influenced the night results. This hypothesis arose from the consideration that the letters were larger than those used in earlier experiments and that as the simulated sign was made darker the constant letter brightness resulted in a higher letter-to-sign brightness ratio.

Effects of Size and Brightness Without Letters

Experiment 7 tested the hypothesis from Experiment 6 that the letter-to-sign brightness ratio had enhanced the effect of the dark sign against the day background and had also caused it to be seen best against the night background as well. The same combinations of size and brightness and groups of four signs were used as in Experiment 6 except that the simulated signs were blank, i. e., carried no letters. If the unexpected results were due to the bright letters, it was hypothesized that we should obtain results consistent with the earlier experiments using blank signs.

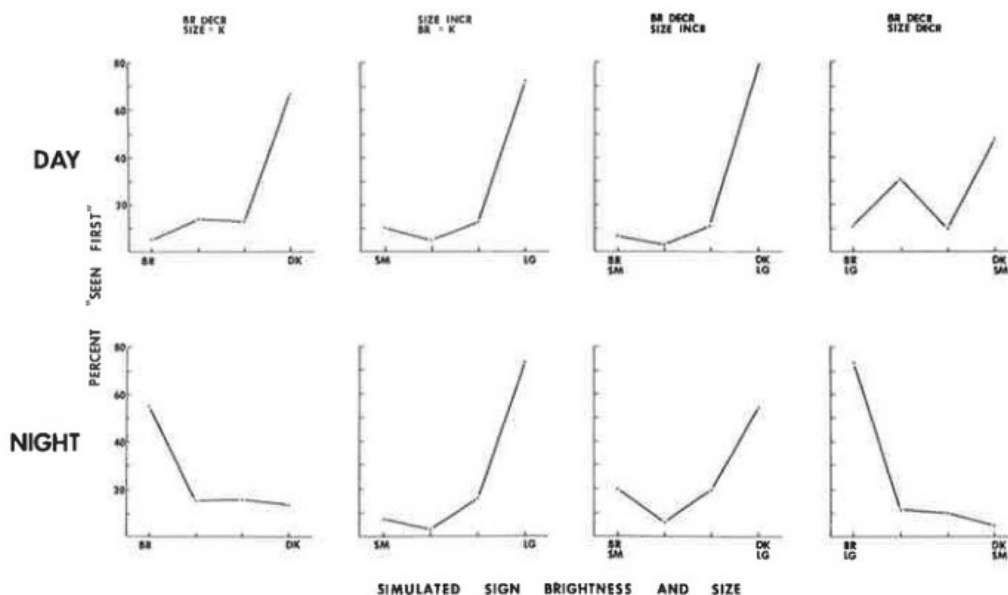


Figure 3. Results of Experiment 7—blank signs.

The results depicted in Figure 3 show that this hypothesis was confirmed. When seen against the day-snow background, dark-and-large were seen best, the two variables enhanced each other where size increased as brightness decreased, and opposed each other when size and brightness decreased together, i.e., bright-and-large, and dark-and-small were seen best more than other combinations.

When seen against the night background, the brightest sign was seen best in the majority of cases as it was in earlier experiments. When brightness was constant, the largest sign was seen best. Where brightness and size increased together, the bright-large sign was also seen best. When brightness decreased as size increased there was a trend toward opposing effects, i.e., neither the brightest sign nor the largest sign was seen as frequently as it had been when the other variable was constant.

Effects of Sign Size and Brightness With Reducing Letter Brightness

Experiment 8 was designed to check in another way the hypothesis that letter-to-sign brightness ratio, because it increased on the darker signs, was responsible for the apparent advantage of the darkest sign against the night background in Experiment 6. In Experiment 8, simulated signs were used having the same size and brightness and the same size letters and arrows. However, the neutral overlay used to reduce the brightness of the simulated sign was placed over the letters as well on signs 3 and 4. Thus, the brightness of the letter was reduced with that of the sign. Sign 1 (in which the background was lightened by a transparent white overlay) in itself reduced letter-to-sign brightness as compared with that of sign 2, which used the most saturated green material available. Thus, brightness sign 2 contained the highest letter-to-sign brightness ratio and the greenest (most saturated) green. Sign 1 was lighter and with a lower letter-to-sign brightness ratio, and signs 3 and 4 (increasingly darker) had proportionally reduced letter-to-sign brightness ratios.

If the hypothesis was correct, the size effect against the day background should occur with less advantage for the darkest sign. Because of the now reduced letter-to-sign contrast, against the night background relations more like those of Experiment 7 should result. The procedure was the same as in the two previous experiments.

The results tended to confirm the hypothesis. The upper row in Figure 4 shows results with the day-snow background. Brightness sign 2 was seen best with size constant. With brightness constant, the largest sign was again seen best most frequently.

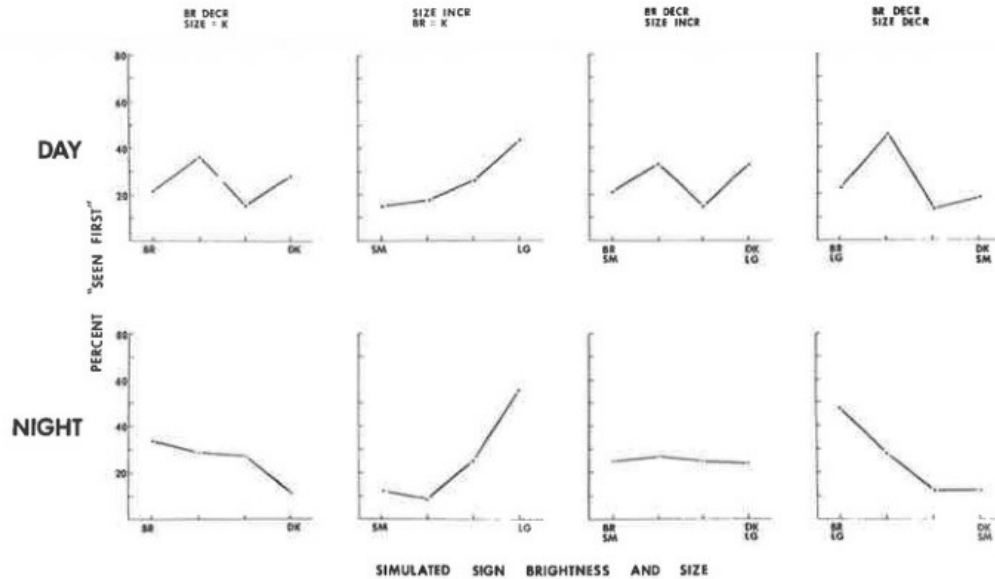


Figure 4. Results of Experiment 8—reduced letter-to-sign brightness.

When brightness decreased as size increased, there was an advantage for the darkest, largest sign and for the second brightest sign, i.e., the highest letter-to-sign brightness and most saturated green. When size decreased and brightness decreased together, the combination of second brightest and second largest was seen best most frequently. Thus, the influence of the letter-to-sign brightness overcame to some extent the advantage of the dark-large sign in the third and dominated the response in the fourth series of combinations.

The lower row of Figure 4 shows the results when the simulated signs were seen against the night background. With size constant, the previous advantage of the lightest sign was equalized with the second and third brightest. With brightness held constant, the dominant advantage of the largest sign remained. When brightness decreased as sign size increased, the opposing effects canceled each other, giving almost a horizontal line. When brightness and size decreased together, the bright-large was seen most frequently, but the second brightest (high letter contrast and saturated green) sign combined with the second largest was seen best more frequently than in Experiment 7.

Conclusions from Experiments 6, 7, and 8

It was concluded from the three experiments that the expected advantage for the largest of four signs was found consistently when the simulated green signs were seen against either day-snow or the night background. An advantage for the brightest of four blank signs was consistent when seen against the night background. Also, for night blank signs, brightness and size enhanced each other where both variables increased together and opposed each other where brightness decreased and size increased.

The bright letters resulted in an increasing letter-to-sign brightness ratio as sign brightness decreased. Against the day background this enhanced the advantage of the dark signs against the day-snow backgrounds. When letter brightness was reduced with sign brightness, the advantage of the darkest sign lessened and the second brightest (greenest, high letter-to-sign brightness) was increased. Against the night background, to reduced letter brightness tended to equalize the advantage of the two brightest signs and to balance the opposing effects of size and brightness.

Thus, it is clear that an advantage for visibility was enhanced by a combination of (a) greater sign brightness, (b) greater relative sign size, (c) contrast of sign against

background, and (d) letter-to-sign brightness. These effects either enhanced or opposed each other, depending on the background against which the simulated signs were seen, and whether the letter-to-sign brightness ratio increased as sign brightness decreased.

Effect of Sign Size and Brightness and Competing Illuminated Signs

The purpose of Experiment 10 was to measure the effect of sign brightness against night backgrounds with competing illuminated advertising signs. Two night background scenes were used. One had a profusion of brightly illuminated advertising signs and the second somewhat fewer and less brilliant competing signs.

The stimulus slides were made using the same four brightnesses of simulated green signs carrying the same five nonsense letters as Experiment 3 (smaller than those of Experiments 6 and 8). Again, these were photographed in color against the two background scenes to produce the stimulus slides.

To increase the range of competing brightnesses, two different camera exposures were used one-half stop apart. This resulted in two presentation series against each of the background scenes, one darker than the other. A total of 40 subjects viewed the slides, 10 viewing each combination of background, advertising signs, and normal or darker exposure.

Both position of the sign, sign brightness, and relation to the background affected visibility. The results when the simulated signs were viewed against the brighter surround are shown in the upper part of Figure 5, and the darker surround in the lower part of Figure 5. The solid line represents the background scene made with normal

exposure (brighter), the dashed line with reduced exposure (darker).

Against the brighter night surround, the darkest of the four signs was seen best more frequently for the brighter exposure and for the right-hand position. This position was next to a large, bright advertising sign. The brightest of the four simulated signs, on the other hand, was seen best against the slightly darker exposure and the left-hand position where competing signs were not as bright.

In location B, which included street lighting but fewer competing signs, the right position was seen best the least and the darkest sign the most frequently. However, the brightest of the four signs was seen best against the background with darker exposure and the darker against the background with the normal or lighter exposure.

Thus, on the whole, the brightest sign was seen best more often against darker backgrounds and the darkest of the four signs against lighter backgrounds and brighter surround. This does not mean that the signs were more legible, since there was no reading of the nonsense letters on the signs involved.

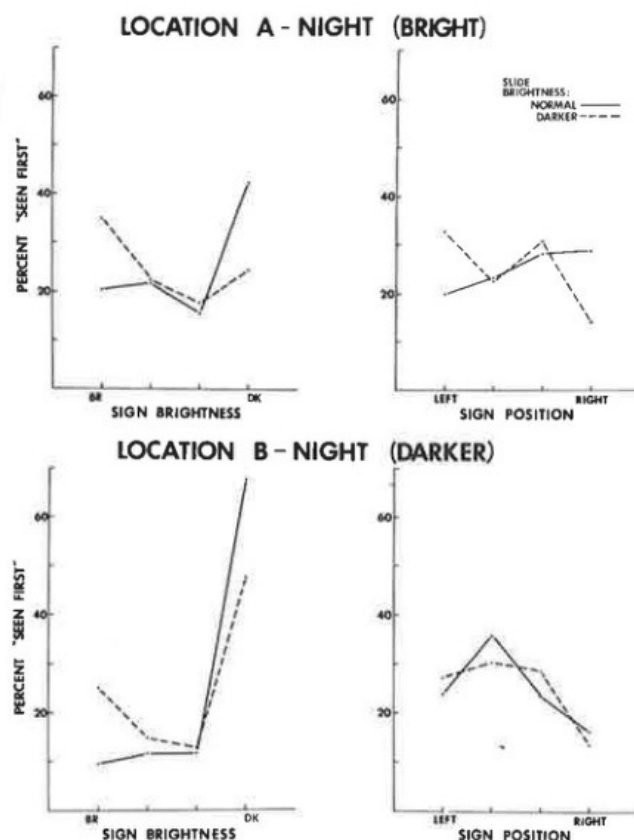


Figure 5. Results of Experiment 10—competing signs in background.

DISCUSSION

The first three experiments confirm previous results indicating that the darkest of four signs was seen best by most observers against a bright background, such as the day-snow background. The brightest of four blank signs also was seen best against a dark night background most frequently.

Adding large, bright letters and symbols to the simulated signs introduced a third influence on visibility or attention value, which depended on letter-to-sign brightness. Constant brightness letters had the effect of increasing brightness ratio as the simulated signs became darker, and this enhanced the attention value of the darker signs. Higher letter-to-sign brightness, therefore, opposed the effect of greater sign brightness against night backgrounds and added to the effect of a dark sign against a bright day background. By reducing letter brightness along with sign brightness the letter-to-sign brightness effect on visibility was reduced. The results with competing advertising signs also showed the advantage of the darkest sign against bright and the brightest sign against darker backgrounds.

These findings suggest that silhouette seeing is of importance for visibility or attention value where signs are seen against a bright background. Consistently, where they were seen against a dark background, the brightest sign showed a definite advantage. It is evident that letter-to-sign brightness ratio is another important variable. Letter-to-sign brightness and contrast also is known to be important for legibility. Therefore an optimum combination of these three variables must be found to obtain best attention value and best legibility.

A further factor being studied is color contrast. This factor may also affect highway sign visibility and attention value.

REFERENCES

1. Forbes, T. W., Pain, R. F., Fry, J. P., Jr., and Joyce, R. P. Effect of Sign Position and Brightness on Seeing Simulated Highway Signs. Highway Research Record 164, pp. 29-37, 1967.
2. Forbes, T. W., Snyder, T. E., and Pain, R. F. A Study of Traffic Sign Requirements, II: An Annotated Bibliography. Michigan State Univ., East Lansing, 1964.
3. Forbes, T. W., Snyder, T. E., and Pain, R. F. Traffic Sign Requirements, I: Review of Factors Involved, Previous Studies and Needed Research. Highway Research Record 70, pp. 48-56, 1965.