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Some Effects of Color on Perception of Relative Motion at Night

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Some Effects of Color on Perception of Relative Motion at Night*

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Introduction

Past research by the present authors (1951) has demonstrated that increasing the visibility of a vehicle at night decreases the time and difficulty for perception of a speed differential between two vehicles traveling in the same direction. Three of the criteria given by Luckiesh (1944), size, contrast and over-all illumination, were used as basic factors for varying the visibility. The contrast between the vehicle and background was varied by using materials with different reflection characteristics on the rear panel. The materials used reflected white light, but the availability of colored reflecting materials has made necessary this pilot study for the evaluation of the use of such materials for increasing the visibility of a vehicle at night. The data herein reported are part of a study on both color and pattern but time and space permit only presentation of the data on color here.

Apparatus and Procedure

The Scotometer, as described by Stalder (1951), was used for making the experimental tests. The procedure consisted of requiring the subjects to report direction of the speed differential as soon as possible after exposure of the target. If the target was moving towards the subject he was to call out the word "slower," if it was moving away "faster." An electronic voice key, Kjerland (1950), made it possible for a verbal response to stop the timing unit, which was started when the shutter opened. The shutter was opened and the clock started automatically when the target passed the point of exposure, 600 feet or the predetermined scale distance. The speed of the target was set for a scale value of 10 miles per hour, and was controlled within a 10 percent error.

Two conditions of the impinging and opposing light sources were used. They were:

1. High-beam impinging but no opposing lights
2. Low-beam impinging and low-beam opposing lights

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The lights were calibrated to be equivalent to 75,000 beam candle power on high beam, and 23,000 on low beam.

In addition to the perception time for each trial, a measure of the difficulty was obtained by asking each subject to respond to the following question: "Was it, (1) very difficult, (2) difficult, (3) average difficulty, (4) easy, (5) very easy, to perceive the direction of movement?" For statistical evaluation values were assigned to the various choices as is indicated.

After the two trials with the distance decreasing and enough trials with the distance increasing to maintain a choice situation, the observers were asked to judge the distance the vehicle or target panel was away when it was exposed. They were instructed that it would be exposed between 400 and 800 feet scale distance. The panel was actually exposed each time at 600 feet, but this aufgabe was used to determine if any target was judged consistently farther or closer than another.

Experimental Targets or Panels

The hypotheses set up for testing in this experiment might be stated in null form as follows:

1. The addition of readily perceptible details to a surface makes no difference in the time and difficulty for perception of its relative motion.
2. The color of the added details does not affect the perception of relative motion.

The following assumptions were made:

1. The normal variations in fixation and reaction time of a subject constituted a negligible source of error between the various experimental conditions used.
2. Variations in the abilities of the observers affected the results of all the experimental conditions in a like degree.
3. Each subject was motivated to do his best on each observation.
4. For application of the results to road conditions the degree of similarity between laboratory and road studies is of the same order as that of previous studies with white reflectorized materials.
5. The variation in reflection characteristic of each type of material did not affect the results in a significant way.

To test the hypotheses the following experimental target panels were selected and used:

1. A 4 x 4½ inch flat-back panel with a reflection characteristic of 0.04. A red taillight was placed in each corner of the panel. The

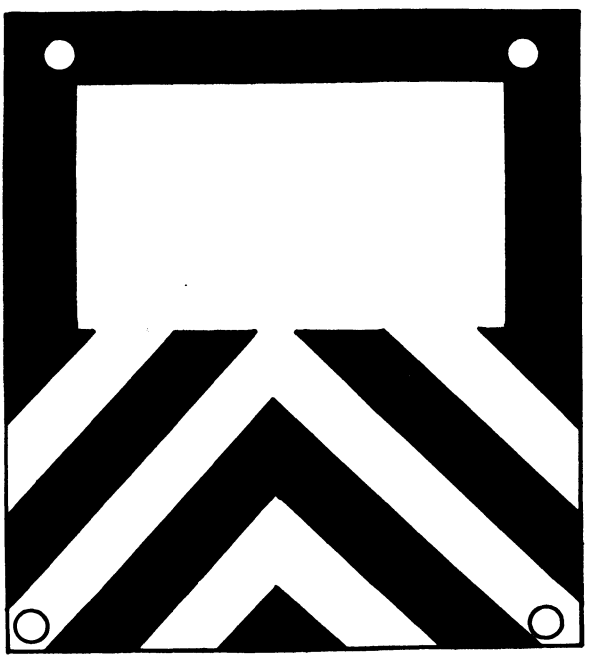
taillight intensity was equated subjectively by comparing the intensity of the laboratory lights at 600 feet scale distance to a 2.6 beam candle power taillight at 600 feet actual distance. Readings on a milliammeter were used to obtain a standard setting.

2. A barrier design in addition to the four taillights as shown in Figure 1. Three separate targets were made using this design. The reflectorized materials used were as follows:

a. Red with a R.C.* of 35
b. Green with a R.C. of 25
c. Yellow with a R.C. of 75

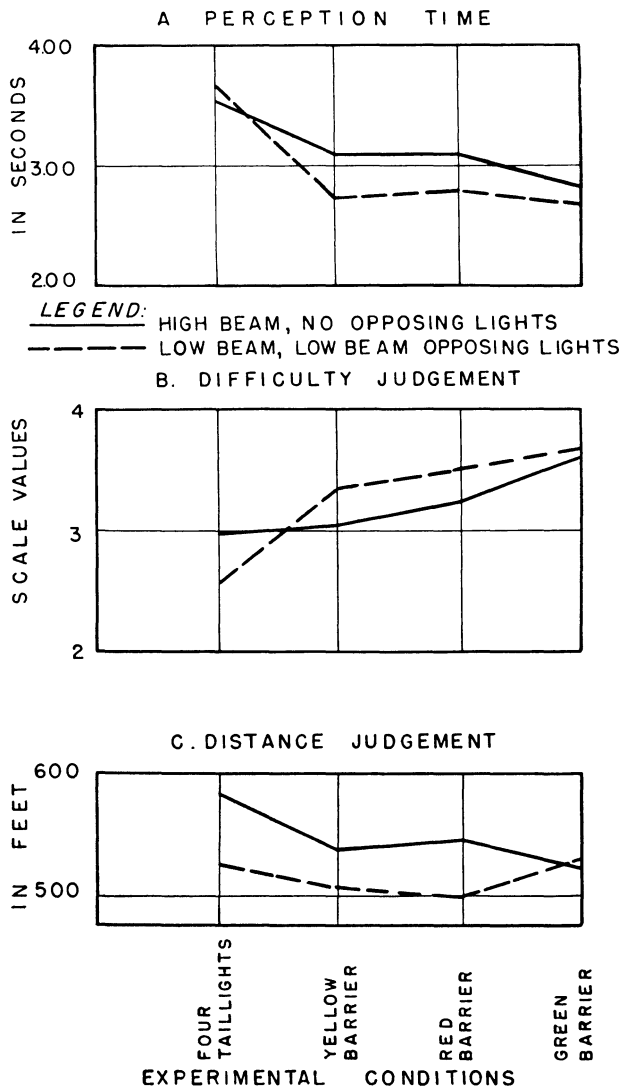
*R.C.—Reflection characteristic.

FIGURE 1
BARRIER DESIGN USED WITH RED, R.C. 35, GREEN, R.C. 25, AND YELLOW, R.C. 75.



LEGEND:
REFLECTORIZED AREA
FLAT BLACK

FIGURE II MEAN VALUES



The reflection characteristics were determined by designating flat-white paint as unity and measuring the relative amounts of light returned towards the source of an angle of divergence of 1/3 of a degree. Experimental control would have been better if the reflection characteristics had been equal, but such materials were not available and previous research had demonstrated little difference once a certain level was attained.

The exterior visual angles were held constant for the four targets. The main variables were the addition of readily perceptible details, and the color of the added details.

Results

The mean values obtained for the three measures for both conditions of the light sources are shown in Figure II, A, B, and C. Because of the greater pragmatic value and limitation of space only the data on the distance decreasing are presented.

The *t* test was used to determine the statistical significance of the mean differences obtained. The differences listed below are significant at the 5 percent level or beyond, unless otherwise stated.

A. Perception time.
   1. High beam—no opposing lights.
      a. Green barrier required significantly less time for response than the four taillights.
      b. Green barrier less than the red barrier at the 6 per cent confidence level.
   2. Low beam—low-beam opposing lights.
      a. Red barrier, green barrier, and yellow barrier all required significantly less time for making decisions than the four taillights alone.

B. Difficulty judgment.
   1. High beam—no opposing lights.
      a. Green barrier significantly less difficult (higher scale values) than the four taillights alone, and the yellow barrier design.
      b. Green barrier less than the red barrier at the 7 per cent confidence level.
   2. Low beam—low-beam opposing lights.
      a. Green barrier, red barrier, and yellow barrier all significantly less than the four taillights alone.

C. Distance judgment.
   1. High beam—no opposing lights.
      a. Red barrier and green barrier significantly less than the four taillights alone.
      b. Green barrier significantly less than yellow barrier.

The reliability of the perception time and difficulty measurements could be obtained by correlating the results on the first trial with

the second trial. The reliabilities for the sum of the two trials, as estimated by the Spearman-Brown formula, are shown in Table I.

Table I

Reliabilities for Perception Time and Difficulty Measurements.

Experimental Condition	*Reliability* Perception Time	*Coefficients* Difficulty Judgment
Four taillights—nothing else	0.731	0.736
Four taillights—red barrier	0.639	0.630
Four taillights—green barrier	0.951	0.768
Four taillights—yellow barrier	0.740	0.624

Summary and Conclusions

Using the Scotometer as the measuring device, perception time, difficulty of perception and distance judgments were obtained for four experimental targets under two conditions of the impinging and opposing light sources. The variations between the targets consisted of the addition of readily perceptible details of different colors. An experimental condition of four taillights and a flat-black tailgate surface was the basis for comparison. Red, green and yellow reflectorized materials were used for addition of the details.

The perception time and difficulty judgments were significantly less for the panels with the added details for the light conditions of low beam—low-beam opposing. Thus, the hypothesis, that there was no difference was rejected for these experimental conditions, and the conclusion drawn that the addition of details did reduce the time and difficulty.

For the color of the added details, the green barrier was significantly less than the four taillights alone under conditions of high-beam impinging lights. The differences between green and the other colors approached statistical significance in some instances. A tentative conclusion might be drawn that the addition of green details was the most effective for over-all results, but further research is required before this conclusion can be definitely stated. Such research would be directed toward determining the interaction, if any, between color and pattern. In other words, one color may be more effective in one pattern, but another might stand out best in a different pattern.

For the distance judgment evaluations there were instances of statistical significance, but since there were not any clearly consistent differences, no conclusions were made.

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