IMPROVEMENT IN HIGHWAY SAFETY

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SYNOPSIS

A review of the work of the Committee on Psychology of the Highway of the Division of Psychology and Anthropology of the National Research Council This Committee was organized as the result of the emphasis placed upon the need for research along this line by the First Hoover Conference on Street and Highway Safety in 1926

Psychologists were asked to investigate this field for two reasons In the first place the National Safety Council estimates that at least 90 per cent of all accidents are directly traceable to the driver The second is that, as a matter of personnel, it is fundamentally a psychological problem in that this younger science specializes in studies of human behavior.

The first studies were made of traffic analysis in specific localities, the actions of drivers having trouble at these places and the nature of such accident locations Very interesting data were found in this study relative to through traffic in cities

Further analyses of drivers in a laboratory situation were carried out In order to extend the study an outdoor test field was devised by means of which about 1200 drivers have been examined Data relative to location of highway signs type and nature of signs which are most legible as well as visible were secured along with certain incidental facts

No more pressing problem relating to public health and welfare than highway safety lies before the American people today It is everyone's problem and all must cooperate to accomplish a more thoroughgoing conservation of life, limb, and property in relation to automotive traffic.

The automobile is indispensable to modern business and any attempt to limit traffic by removing cars from the highway will prove highly impractical Better communication and transportation facilities mean closer national unity and economic security Good roads are at the basis of intra-sectional transportation The progress of the United States during the past decade in this direction has been nothing less than phenomenal Our highways have been extended from coast to coast and from border to border Wide curves have taken the place of sharp right angle turns These curves have been banked for speed of modern vehicles Three and four lane highways have in many places supplanted the old narrow concrete ribbons. Specially devised intersections of mono-plane or duo-plane construction have become com-

mon Markers have been simplified and many other safety devices have been inaugurated such as stop lights, double lines on the pavement, warning signals, etc In spite of these precautions our accident rate has gradually increased when the number of cars registered is considered.

Engineering developments in the field of safety have been very rapid. Often, however, a change of method and the introduction of new principles will greatly aid progress The development of the automobile depended upon the perfection of a light, throttle-fed, gasoline motor. Modern broadcasting is a direct consequence of the perfection of the vacuum tube Marconi had progressed as far as he could without new principles

The new element or principle we propose for improving highway safety is consideration of the driver at the wheel. Human beings differ widely in many ways It is the function of the committee on "Psychology of the Highway" to investigate ways in which persons differ and which affect their efficiency in driving

One assumption which has been tacitly accepted through the common channels of public opinion is that accidents occur by chance Any thinking person realizes the fallacy of such a doctrine, and of course those interested in promoting safety cannot accept it as tenable. There is always a cause for an accident The cause may reside in the driver, in the automobile, in the roadway, or it may be due to distracting influences which are extraneous to the highway proper. To illustrate the latter point by a simple situation: Suppose a driver is coming up to a clear intersection. Normally he may look to the right and to the left in order to be assured of the right-of-way. He drives on with assurance of safety Suppose, on the contrary, that he approaches a similar intersection in the same car, at the same time of day, and under almost identical conditions Let us further suppose a tobacco advertisement has just been placed on a sign board at the right of the intersection in a very conspicuous place If the "ad" carries some sentiment which particularly annoys the driver he may "flare up" emotionally By such annoyance the attention is lowered He fails to look both ways and a crash ensues with a car coming along the side road (Figure 1)

All "ads" will not affect all people, nor any two, in the same way There may be incidental distractions due to mental set At any rate it is practically impossible to discriminate against certain types of advertisements at or near intersections and the matter resolves into a problem of how close they may stand without becoming a general menace This is linked up with other factors such as the complexity of the intersection, the nature of the markers used, and the susceptibility of the driver to distraction It may be shown more concretely in the form of a tri-dimensional graph as in Figure 2

Let us use a triangle to show this relationship. Let one side represent

the driver, another the intersection, and the third the efficacy of the markers used. Lines drawn perpendicular to and bisecting each side are used as the respective axes. Now if the intersection is good, markers are clear, and a good driver passes by there is ample margin of safety. If a poor driver comes by there may be certain danger. The danger area however will be inversely proportional to the length of the axes standing for the simplicity of the intersection and the efficacy of the markers.

Another wrong conception regarding drivers is that all are alike. That is to say, a marker or other stimulus which is not confusing to a few select observers will not be confusing to anyone. This is entirely false. Our studies of some two thousand drivers from different sections

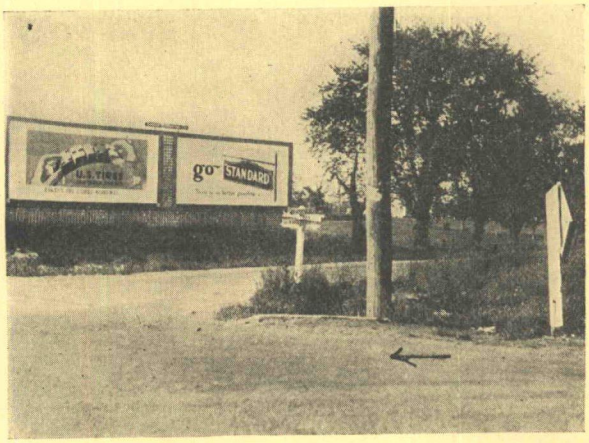

Figure 1. Showing a Typical Highway Intersection with Large Sign Boards Which Distracts Attention

Such stimuli act as distractions to say the least. What chance have the small workers on the post with such competing stimuli?

of the country have quite clearly established the fact that three types of individuals are to be found on the highways. The first is the group of accident-free consisting of 70 to 75 per cent of all motor vehicle operators. They will have little trouble under any ordinary circumstances. The second group we have designated as accident-liable. They make up some 20 to 25 per cent of the total number. These drivers have trouble from various subtle causes. Some are irresponsible, some are preoccupied through illness, domestic affairs, etc., while others may be careless. All their difficulties perhaps go back to either hereditary or environmental conditions which influence the individual. At any rate they are a menace to traffic and the odds must be stacked in their favor to promote the greatest safety. It is for this group that

the highway engineer must strive to provide as nearly fool-proof roadways as possible

The third group of from 2 to 5 per cent of the drivers consists of those generally designated as accident-prone Usually outstanding defects are found in this group Some common types are color-blindness,

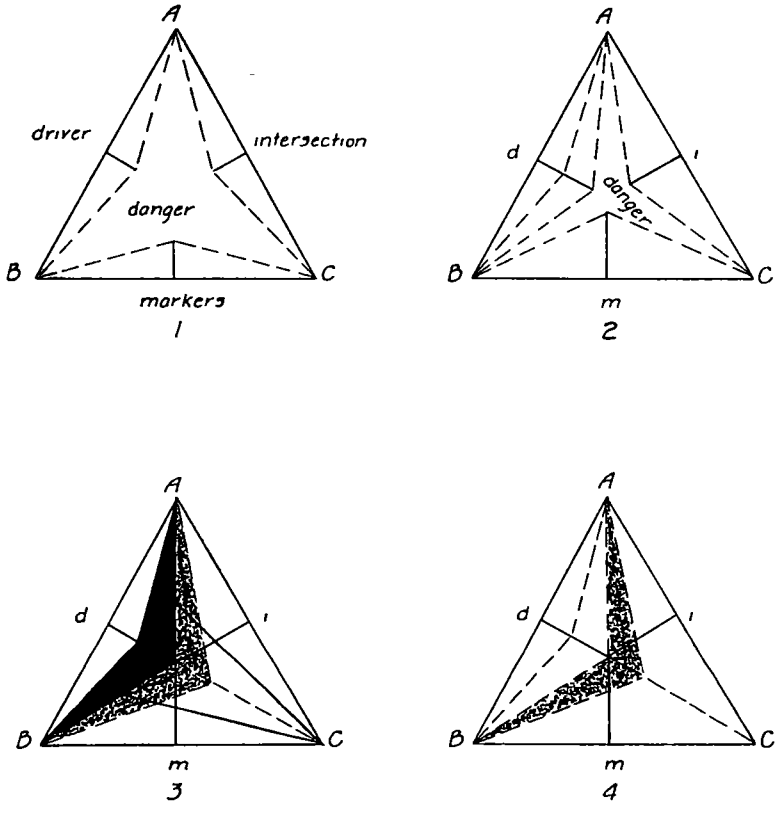

Figure 2. In (1) the driver is low in efficiency along with the other two facts indicated At (2) all are improved. The danger section is decreased but a hazard still exists In the drawing at (3) the intersection and the marking system are efficient enough to reduce the danger to zero even when the driver is inefficient. The shaded and black areas show the margin of safety for an excellent driver. The black area shows the margin of safety for an average driver In (4) where the intersection is average a margin of safety is shown for the excellent driver by the shaded area. A danger area also exists for the careless or poor driver.

restricted field of vision, diplopia, lowered visual acuity, narcolepsy, extreme nervousness, poor coordination, etc Special consideration must be given such drivers This becomes especially apparent when we consider that half the accidents are caused by 7 per cent of all drivers Various ways these people may be helped will be by types of improvements suggested in the following pages

To summarize the last few paragraphs *It is fundamental to the improvement of highway safety that different types of individuals be considered and that safety measures be provided which will make it easy for the accident groups to keep out of trouble* Our committee has worked with two fundamental objectives in view. (a) to facilitate traffic flow, and (b) to promote safety in driving With these two objectives as a guide we have set out to gather four types of data (1) Studies of drivers' reactions in actual, semi-practical, and laboratory situations (2) Analysis of factors relating to quick and easy identification of speeding cars by improved license plates (3) Analysis of road situations, markers, and other signals for making the simplest possible signs for directing traffic (4) Laboratory studies of optimal colors for stop lights, road markers, and related items A digest of results will be presented along with some general psychological principles involved I shall not go into details on all these points The third and fourth categories only will be of direct interest to members of this assembly They are of course dependent upon ground work done on the first two from which I shall draw considerable data

At Dayton, Ohio, we analyzed four years' records of a certain commercial organization aggregating 538 accidents upon which data had been carefully collected When the number of miles driven was considered these drivers had fewer accidents in the winter months than at other seasons of the year This means that conditions of traction alone is contributory to accidents with only a certain class of drivers All of these men came in the accident group, yet they took pains to allow for icy streets and slick pavements Analysis of the latter factors showed the streets to have been dry in 80 per cent of the cases It is suggestive of the need for strict enforcement of safe driving practices either through education and the development of public sentiment or by highway patrols A driver's license law with "teeth" seems one of the most effective measures

The need for care in routing highways is brought out by the fact that 4 8 per cent of the streets of Dayton had 53 01 per cent of the accidents The three main streets, about one per cent of the total, which carried cross country highways had 26 8 per cent of all the accidents It is true they were longer but the comparison when corrected for actual street miles is greatly onesided

This study is not new but illustrative of one local condition and it suggested further analysis of conditions at the intersections. At Main and Monument, a serious danger point, several confusing factors were found There is a massive Civil War Veteran's monument in the middle of the intersection Not only must traffic move around this obstacle but at the same time the view is obstructed Lights are placed only on the near side of the street and once past this point the driver does not know when to expect a traffic change without looking off at a sharp

angle Street cars turn on the red lights at this point which further confuses out-of-town drivers A nervous person is thrown into a panicky condition by the multiplicity of stimuli which are presented at such places So acute is this location that we actually got a minor accident while photographing a fake one with the aid of the police officials

This particular location brings up many other problems basic to which is the matter of how many things a person can attend to at once The range of attention, as it is called, has long been known to classical psychologists to be unity That is if we are to be absolutely sure of what we see, hear, or otherwise sense and interpret only one object at a time should be presented This attention span or range, of course, is larger in most practical situations because the units of the situation combine into higher units or do not require perfect analysis For this reason we may have several items presented at once with little chance of confusion When more than six unit objects are presented at once the efficiency of the attention drops off rapidly for each License plate numbers of more than this number of characters are much inferior

Certain accident locations have been analyzed which have twelve or more major items of attention A filling station, road-house, oil signs, three or four type of markers, and other objects comprise these items Some few persons can get 8 or 10 objects at a glance but this is exceptional Time studies were made of the length of time necessary for a person to read the legend on the sign boards of one intersection of this type The average time of several readers was 9.7 seconds When asked to get the directions to certain towns the average observation time was 30 7 seconds Only 65 per cent correct responses were made to questions asked about the intersection A driver traveling at 30 miles an hour would move some 1351 feet while reading the directions These signs are usually placed at less than 50 feet from the intersection and are visible to the person with normal vision (20/20 Snellen) at a distance of 150 to 160 feet The average driver has but 91 per cent vision.

Contrast the cluster of names in Figure 3 with a simple sign using an arrow and one word The reading time of this marker was 3 6 seconds It took 11 seconds for careful observation after which 100 per cent correct responses were made by all persons. While it is true that highway officials are faced with strong conventional practices of printing out names in full so no towns will be slighted there is need to eliminate the more elaborate markers If names must be posted there should be a signboard placed on a siding at some distance from the intersection. Persons unfamiliar with the road could stop and inform themselves without blocking traffic

In the central west the markers are quite well standardized as to form, size, color, location, etc The diverse practices in some of the eastern states may be noted by a short trip through some of them. Delaware

has recently experimented with a sign similar to those used in Canada. The direction of the roads is shown on the marker by drawings. It seems ideal. A pictographic marker as in Figure 4 is usually much clearer and more easily understood. On our driving field the small markers with arrow pointers are found to be superior to those marked L or R for right or left. Many people are momentarily nonplussed when asked to go to the right or left. If the direction is clearly indicated these difficulties tend to disappear.

From inquiries we have received I am sure you are interested in certain aspects of color. A marker must have three specific qualities for highest efficiency. It must be noticeable and stand out from the surrounding objects. By the laws of color contrast we know the maximum effect is produced when complimentary colors are used adjacently.

Figure 3. This illustrates a type of complex intersection described in the text. Not only are the signs complex but the intersection itself has many items which may lead to confusion.

A marker must be suited to all seasonal changes: browns in the fall and spring, white in the winter, and green in the summer. A color which seems best suited to all these seasons is a canary yellow with a wave length of about 5700 Angstrom units. It is also good under low degrees of illumination as discussed in a paper published jointly by a junior author and myself. This article appeared in American Highways of April 1932. Measurements were made by means of the Razek-Mülder Color Analyser.

New York has adopted a cream yellow which resembles gold paint from a distance. It is quite good but a slight amount more of the yellow chroma would probably aid somewhat. The human eye is more sensitive to yellow bands of the spectrum which further strengthens the argument for this color.

Of course a sign can be too spectacular and attract so much attention that the passerby forgets his driving. For this reason they should be simple, only large enough to be seen well, with a background which contrasts both with the environment and the legend. Photos made

Figure 4. A Simple Type of Marker Using Pictographic Principle. The Legend Is Secondary

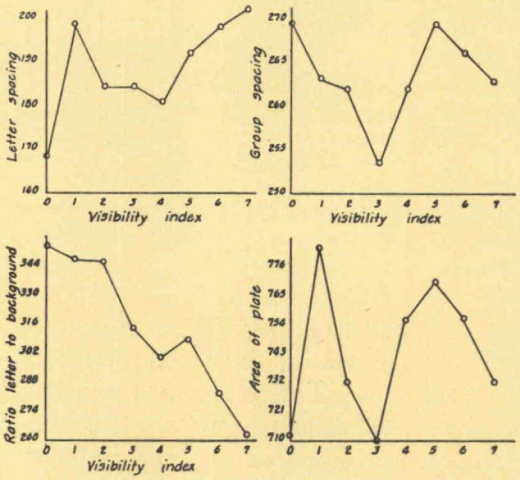

Figure 5. Relation between Spacing and Legibility
Signs would be much more legible if the legend did not exceed 20 to 25 per cent of the area.

with panchromatic film indicate to some extent the difference in effectiveness of various colors. We have analyzed the colors of numerous license plates to get more information on optimal colors for background and legend. Dark letters on a light background are found to be better

than the reverse. This is probably due to a retinal condition of the eye as visual acuity is higher when the eye is adapted to moderate intensities of light.

Tints of blue-green, yellow-green, yellow, blue, violet, red, and yellow-orange were found best for backgrounds. Shades of blue-green, orange-red, violet and blue were found best for letters. Black and white are

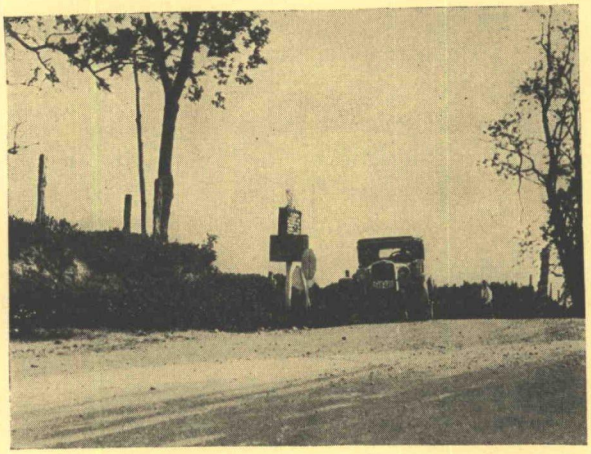

Figure 6. A Meaningless Cluster of Signs

Figure 7. Large Signs Are Sometimes Good if They Do Not Obscure the View

not considered as colors but are always good. Navy blue, very dark reds, and dark greens are nearly as good as blacks. Dull colors are better than glossy ones for letters. Semi-reflecting surfaces such as aluminum are good for backgrounds if properly located with respect to the rays of impinging light.

Some recommendations have been made relative to the height-width

ratio of letters. To review slightly, this ratio should not be less than 0.33 considering economy in spacing. Block letters spaced closely are not as legible as more slender letters spaced further apart. A practical rule is to space letters 50 per cent of their average width. This means that I's will have more room than ordinarily allowed and M's or W's will have about the same. A stroke of about 20 per cent the width of the letter seems best.

Recently we have begun a study with color-blind persons to determine the best colors for stop lights. A spectrometer and a spectrophotometer are used for matching colors. We find color-blind persons are nearly as capable as normal individuals in matching most bands of the spectrum. The average error for normal observers is about 50 Angstrom units while that of color-blind persons is about 55 Angstrom units. Least confusion was obtained in regions of 6500 and 4900 units respectively.

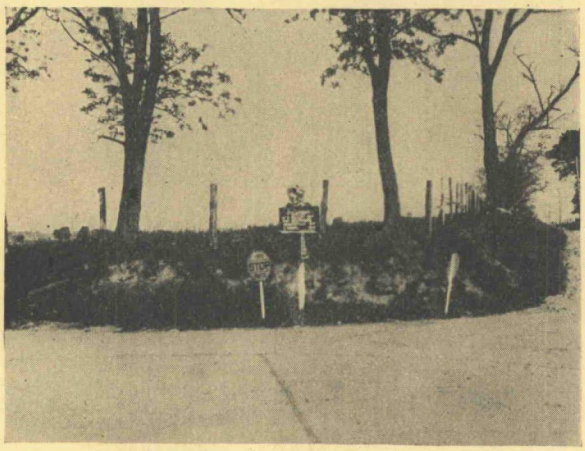

Figure 8. One Would Need a Telescope to Figure This Marker Out

In certain cases however there is danger of confusion of red and green by some types of color-blind individuals. While our experiments are not completed it seems this range is between 5000 to 5200 Angstrom units in the green and between 6100 to 6300 Angstrom units in the red. This means that adjustments will need to be made at both ends of the spectrum for best discrimination of *Stop* and *Go* lights. Previously the adjustment has only been made in the green. More data will be available on this point soon and these statements are only tentative. Further it is quite certain that intensity is not a prime factor of discrimination of colors by color-blind individuals. The Ishihara test will catch all who might fail to discriminate colors if it is properly given and interpreted.

Another matter I should like to mention is the angle of declination from the line of vision at which stop lights and various other signs,

markers, or signals are placed. According to Koester the acuity drops off rapidly as the distance from the fovea, or spot of keenest vision, increases. At an angle of 10 degrees declination the acuity is 28 per cent. At 20 degrees it is only 14 per cent. This means that a marker placed at any distance to the side of the road loses efficiency rapidly. The proper angle at the optimal distance of reading is a matter which must be determined in terms of the variables involved.

It is hardly necessary to mention the hazards introduced by pseudo-warning signs put up by roadside lunch houses, oil stations, etc. The general psychological effect of adaptation increases the danger. In common parlance this means the same as that describing the ultimate condition of the shepherd boy's parents when he kept called "Wolf,

Figure 9. Compare the Size of the Traffic Marker with the Large Private Sign Located Just Back of It

wolf." They refused to become alarmed. This principle is known in psychology as adaptation. Not only is it necessary to have the signs real but there is an optimal point in the amount of bona fide markings. Too many signs or markers, like too many laws, are not always taken seriously. The optimal point of marking is a matter to be further investigated.

Numerous other problems are looming in this field. I have tried to call your attention to some of the most pertinent and those which we have studied to some extent. If there have been any new ideas engendered by this paper which will in any way help simplify, unify, and standardize our highway traffic markers, I shall feel more than repaid for the efforts required in collecting and presenting this material.

DISCUSSION

ON

IMPROVEMENT IN HIGHWAY SAFETY

MR BURTON W MARSH, *American Automobile Association* I should like to ask Dr. Lauer if he has made any research into the question of shapes of letters for traffic signs My opinion from numerous observations and some study is that words made up of "block" letters in which, for example, an "O" is practically rectangular, are considerably harder to read than words in which normally curved letters or portions of letters are shown "rounded " On traffic signs it is usually necessary to space letters rather closely Perhaps especially under these conditions, many of the "block" letters tend to look like similar rectangles when viewed from a distance In other words, by this system of lettering, there is a tendency to reduce these differences in shapes which enable us to distinguish between letters Letters with curves fully rounded, on the other hand, present much greater distinctiveness to the eye.

PROFESSOR LAUER We have made more of a study of numbers than letters However, it is known by many authorities who have studied reading and printing that the top of the letter is the distinguishing characteristic of the letter If you try reading a line and cut off the top of the letters it is rather tedious to get the meaning

Dr Tinker of the University of Minnesota has made some elaborate studies on the different sizes and types which are most legible It is certainly an important problem and I would hesitate to answer as we have studied only numbers We find a number having a stroke one-fifth the width and which is constructed in such a way for example, that a 9 is distinctly marked off from an 8 or a 6, is much superior It might be interesting for you to investigate typed copy made on the new Corona with capital letters slanted slightly It seems that these are quite legible It certainly is a good problem but we have not covered that phase yet

MR H S MATTIMORE, *Pennsylvania Department of Highways* I would like to ask relative to sign colors, how much is the background a factor? Are your tests made under different background conditions and what would be the effect in practice of atmospheric conditions or settings of the signs

PROFESSOR LAUER The observations were made on backgrounds of neutral gray or black They were made out of doors in daylight Later other observations were made under artificial illumination using the same background Of course it is hard to duplicate any practical

situation but background is a factor Do you think it possible to select a color which may be standard over the country?

MR MATTIMORE. Would you consider it advisable to standardize throughout the United States rather than in smaller areas or sections

PROFESSOR LAUER That is a good point It may be that in desert regions you should have different colors than in the eastern sections where foliage is green a large part of the year

PROFESSOR DICKINSON What information is there as to the relative effectiveness of symbols as compared with letters for warning signs?

PROFESSOR LAUER We do not have enough information to give you a real answer to that Throughout psychological circles, and I am sure Dr Poffenberger will bear me out, experiments indicate that the symbols should be most effective With children's text books we use all the pictures we can The human mind is of such a nature that when preoccupied it is likely to revert to primitive stages At times of emergency symbols seem most effective

If we are going to have any instructional matter along the highway I would say, instead of having such cluttered-up intersections, let it be placed along the road a half mile before the intersection A sign might convey to you that Baltimore is on No 44 to the left, etc Persons who know the country might go along about their business while the fellow who does not will get his directions without holding up traffic