controlled field measurements; and we are currently developing a field-based system to capture and digitize scenes and apply the model.

The five laboratory studies all used photographic slides of behind-the-wheel driving views. These experiments evaluated subjective difficulty, viewing time, and eye movement, using a number of different experimental procedures. The various measures all intercorrelated substantially. The subjective judgments of "how difficult a view is for driving" were especially effective measures, showing good agreement among subjects, a high degree of replicability, excellent agreement between different methods, and accounting for nearly half of the variance in the data.

The scene difficulty judgments were correlated with a formal model of scene complexity, which we term an "instability" model. The model is relatively simple. It does not attempt to isolate or identify individual scene elements, or the structure or organization of the scene. The image is analyzed globally, and the logic is based on current perceptual research on visual analysis of information at different spatial frequencies. Low frequency components may be processed more rapidly and provide the gross information on general form; they are more resistant to many forms of visual degradation, including defocus. The resistance to defocus, or stability of the image, is a function of the spatial frequency and the degree of contrast.

A mathematical model of the potential information loss through defocus was developed wherein the term "contrast" is used to describe the luminance gradient within the scene and the "complexity" is the second derivative. The images, actually photographic transparencies, are first digitized to convert the image from the continuous tone of the photograph to a matrix of gray-scale values. These values are differentiated both horizontally and vertically. In the particular model described here, a composite measure of contrast and complexity, which is the amount of complexity per unit contrast, is viewed as the critical measure. This is termed the instability score.

In applying this model, the original matrix of the digitized image was compressed by averaging blocks of pixels, analogous to low pass filtering. Weighted combinations of the "instability" measure at different compressions were used to yield an overall index, which was correlated with the subjective ratings of the scenes. Various combinations of compressions yielded multiple-R values of from 0.83 to 0.87. Given the preliminary state of the model, these correlations indicate surprisingly good prediction.

A detailed analysis indicated that the subjective ratings appear highly influenced by the low spatial frequency aspects of the scene. This probably relates to gross roadway contour, alignment, and roadside features. The complexity expressed by the instability model is non-intuitive and does not necessarily relate to a subjective impression of "clutter". Ease of gross path identification apparently contributes more than the presence of many objects.

In the current phase of the project, we are developing a system for more efficiently capturing and analyzing scenes with the model. In the previous work, we had to rely on a multi-stage procedure of photographing scenes, developing slides, digitizing the photo-images through an outside service, and transferring the data to our computer for analysis. Such a multi-step process leads to delay and opportunity for noise, error, or miscalculation. It is not flexible for field use in easily identifying sites of interest. The system we are now developing is a micro-computer-based system using off-the-shelf components and video recording. It should provide a more flexible, timely, and cost-effective system, facilitating use of the instability model or other image-analysis methods.

DAYTIME CONSPICUITY OF ROAD TRAFFIC CONTROL DEVICES

S. E. Jenkins and B. L. Cole, Australian Road Research Board, Vermont South, Australia

The paper addresses the concept of conspicuity, how it can be measured and the means by which the daytime conspicuity of traffic control devices can be enhanced. In the road environment there is an enormous influx of visual information with which the driver has to contend. It is essential that priorities be allocated to this information so that the driver directs his attention to only those facets which are necessary for his purpose and safety. Some degree of pre-attentive processing of all information must occur so that the important information is not discarded but progresses to the stage of consciously being used. The information which the traffic engineer wishes to convey to the driver must be conspicuous, legible and comprehensible at this pre-attentive level of processing. Conspicuity is then an attribute of an object within a visual context which will ensure that its presence is noticed at the pre-attentive level of processing. Engel (1976) distinguishes between "sensory conspicuity" -- the degree of visual prominence afforded to a sign due to its crude sensory features -- and "cognitive conspicuity" which arises from the object's meaning, novelty or relevance and will be dependent on the psychological state of the driver, his purpose and expectancies at the time.

Two methods of measuring conspicuity have been developed at the Australian Road Research Board and Melbourne University. One is a laboratory method (Cole and Jenkins, 1980) derived from an operational definition of sensory conspicuity which states that a conspicuous object is one that will for any given background be seen with certainty ($p > 90$ percent) within a short observation time ($t = 250$ ms) regardless of the location of the object in relation to the line of sight. The other is a field trial (Hughes and Cole, 1983; Cole and Hughes, 1984) which uses a verbal report method which must include both sensory and cognitive conspicuity as well as observer variables. In the field trials the level of attention of drivers was manipulated by using two different instruction sets which enabled two aspects of conspicuity to be investigated; "attention conspicuity" which is the capacity of the traffic control device to attract attention when the driver is unaware of its likely occurrence, and "search conspicuity" which is the ability of the traffic control device to be quickly and readily located by search.

Conspicuity can only be discussed in the context of complex backgrounds. If the target is in a uniform background then we must speak of its visibility. To talk of conspicuity the target must have to compete with other objects for the attention of the driver. The major problem is the quantification of the complexity and defining what background objects form the population of items which can be confused with the target. In order to tackle this problem directly, a series of experiments were carried out. These involved:

1) the detection of a disc in various schematic backgrounds
2) the detection of a disc in a road scene
3) the detection of traffic signs in road scenes
4) field trials of discs and traffic control devices.

The results of the experiments using schematic random arrays of discs showed that the number or density of background discs has an adverse effect on the conspicuity of the target disc if it is detected by virtue of its luminance alone. If the target disc differs from the background discs by virtue of its size, then the background density has no effect at all. If the background discs varied in luminance then this was found to have no measurable effect on the conspicuity of the target disc. If the background discs varied in size then this did have an adverse effect on the conspicuity of the target disc but one which can be predicted by a single model.

The studies of traffic control devices in the road environment showed that size and edge contrast were important determinants of conspicuity. In both the laboratory experiments and field trials it was noted that while regulatory signs did poorly, symbolic signs were more more conspicuous than their alphabetic counterparts and the more visually cluttered the road environment was, the poorer was the conspicuity of the traffic control devices.

The practical implications that have emerged from the research so far are:

1. The important variables which determined daytime conspicuity are the size of the object, its contrast with the immediate surroundings and the complexity of the background.

2. If a sign is to be noticed by a driver, it will be within 10^{o} of his line of sight. When the eccentricity of the sign becomes greater than this then the sign is most unlikely to be noticed at all.

3. The present size of road signs (400 mm to 900 mm) is sufficient to ensure that they should be conspicuous. That they are not is due to their insufficient contrast and/or a high degree of visual clutter.

4. Traffic engineers should be aware of the importance of controlling sign contrast. The means by which this can be done is by careful placement or by allowing a high contrast surround to be placed around the sign as with traffic signals. The dimensions of such a surround are at present under investigation.

5. The degree of complexity of the background is a major variable affecting conspicuity and a means by which it can be measured must become available. Experiments have shown that subjects can rate complexity with some degree of precision, but an objective measure is preferable. It is suggested that there are two aspects of complexity:

   a) Clutter where the target has to compete with other similar objects. The effects of these similar, or confusion elements can be countered by sign design if the confusion elements can be identified, if their size distribution is known and if their average reflectance is known.

   b) Distraction elements: these elements are not necessarily similar to the target, but will attract the driver's attention. The act of noticing irrelevant information will take time and thus increase the demand load on the driver as less time is then available for the driving task.

6. Not all traffic control devices need to attract the attention of the driver. Some devices are needed by only some of the drivers; e.g., direction signs, parking signs and so on need only be acquired when searched for. Appropriate sign design should make it possible to develop an orderly hierarchy of road signing.

SIGN LUMINANCE REQUIREMENTS FOR VARIOUS BACKGROUND COMPLEXITIES

Douglas Mace, Robert King, and Greg Dauber,
Institute for Research, State College, Pennsylvania

The federal standards for luminance of retroreflective materials for traffic signs are absolute; they provide no differentiation based upon driver need. Driver needs for sign luminance are of two types -- luminance levels that define sign legibility and luminance levels that define sign conspicuity. A primary reason why the standards do not reflect these fundamental driver needs is the absence of conclusive data supporting practical and reliable guidelines and the fact that available luminance is dependent on several factors other than the specific luminance of sign material.

Research groups that have recently studied sign luminance and conspicuity include Cole and Jenkins, 1980, 1981; and Mace, et. al., 1982. Both groups call attention to the importance of background complexity in the study of conspicuity. Cole and Jenkins state: "No object is conspicuous per se. It can only be conspicuous in a certain background; if the background changes then the object may or may not remain conspicous." Mace, et. al. expanded this observation, giving equal importance to the role of driver motivation and uncertainty.

> "Conspicuity, like visibility and legibility, is not an observable characteristic of a sign, but a construct which relates measures of perceptual performance with measures of background, motivation, and driver uncertainty."

This recognizes that a stop sign is more conspicuous to the driver who is alerted that one is imminent, or a guide sign is more conspicuous to drivers traveling to the location designated on the sign.

Mace, et. al. operationally define conspicuity as changes in target (e.g., sign luminance) or concomitant changes in surround or scene which will