CHAPTER 2

On-Premise Signs and Traffic Safety

By Douglas Mace

Traffic engineers understand that drivers use many roadside features other than public highway and street signage as navigational aids. Some of those roadside features are commercial, on-premise signs.

In fact, these signs may be just as important to wayfinding as street names, addresses, and highway directional signs. Recognizing that importance, this chapter, based on traffic engineering research about highway signs, will explore three important factors that affect the behavior of drivers and the effectiveness of signs. Those factors are:

- conspicuity or visibility, referring to how distinguishable a sign is from its "surround," which is a term used to describe the area around the sign that the a viewer sees from the location where the viewer would ideally detect the presence of the sign (in other words, how "conspicuous" the sign is given the elements in the area around it);
- legibility, which is related to a viewer's ability to make out the symbols (e.g., letters, icons, etc.) that constitute the sign, a factor dependent on distance and the viewer's eyesight; and
- recognition or readability, which describes how well the viewer can understand or make sense of what appears on the sign.

The chapter first addresses three hypotheses about the relationship of commercial signs to traffic safety. It then describes the engineering practice of Positive Guidance and the relationship of driving tasks, driver cognitive behavior, and the principles of Positive Guidance. This is followed by a section on guidelines that the business community, sign makers, sign regulators, and citizens might find helpful in determining how to make commercial signs visible and readable in a way that enhances economic activity, community appearance, and traffic safety.[1] Finally, it describes a process, cooperative triangulation, that might help communities reach a consensus among all the parties affected by signage issues. Firth (Transportation Research Circular, in press) has cited examples of this process that have produced positive results.

RESEARCH RELATING ON-PREMISE SIGNS AND TRAFFIC SAFETY

While there has been research directed at electronic message signs and billboards, there has been very little published research into the relationship of on-premise signing and traffic safety. The research that exists appears to explore the validity of two hypotheses that have sometimes been generalized to include on-premise signing.

The first hypothesis is that commercial (including on-premise) signs distract drivers and result in more accidents. This hypothesis suggests that advertising signs are traffic hazards because they distract a driver's attention from the primary driving tasks and, therefore, increase the likelihood of accidents. This may occur when a driver samples (i.e., looks at or pays full attention to) the traffic environment too infrequently for conditions. Without advertising displays, the driver may sample the roadway more frequently, providing a greater margin of safety.

The second hypothesis is that commercial signs mask the visibility of highway signs, which also results in more accidents. Advertising signs may provide background luminance, color, or movement that could make a traffic sign or signal of greater importance more difficult to detect. For example, Jenkins (1981) and Mace et al. (1982) have shown that the visual complexity of a scene reduces the likelihood of traffic sign detection. The problem can be circular because signs may contribute to visual complexity that reduces the conspicuity of other signs. Complex scenes reduce conspicuity, and conspicuity, together with information value, determine what signs are noticed.

The problem with both of these hypotheses is that they emphasize only the possible negative effects of commercial signs on traffic safety. Working from that premise alone, one can never prove that signs are good, only that they are bad. Therefore, these hypotheses and the conclusions that follow from testing them are limited.

Johnson and Cole (1976) point out that, in general, drivers' sampling *must* be sound; if not, there would be many more accidents in the vicinity of advertising signs. Also, they suggest that drivers can ignore information that they judge to be irrelevant or when they are preoccupied with a more important task. We would agree that "in general" this is all probably true. What concerns traffic engineers are the exceptions to the "in general" rule. Accident reduction is always concerned with the exceptions, not the rule.

Whatever the truth of these hypotheses,[2] there is a counter hypothesis that better serves the public interest by emphasizing the positive effect of all signing on traffic safety. That hypothesis simply states that information deficiencies increase the likelihood of accidents. This is true whether the deficiency is caused by distraction so that drivers do not attend to important information, by masking that prevents drivers from seeing information, by information overload that results in drivers missing information because they lack sufficient time to process it, or by the complete absence of information at the point where drivers need it. An information deficiency exists when needed information is not there at all, is not visible enough to be recognized at the required distance in the existing lighting conditions, is not presented with sufficient time to process it, or is not located within the "cone of vision" (i.e., the area in which a driver has a generally clear view of objects in and around the roadway).

The deficiency hypothesis suggests that sign deficiencies foster driver uncertainty and, therefore, increase the likelihood of an accident. Schwab (1998) noted that "traffic safety is not jeopardized by the sign itself or some type of stimulus overload; instead the culprit is inadequate sign size or lighting, or inappropriate placement, or a combination of these factors." He concluded that the proper use of on-premise signs could become a "major tool for enhancing public safety." Specifically, he set out to establish a minimum visibility threshold to assist sign makers, sign users, and public officials in identifying and eliminating deficient signing.

To expand the applicability of this alternative hypothesis, sign deficiencies should be defined in a very broad sense to include:

- too much irrelevant information for the current traffic circumstances;
- too many competing signs masking the visibility of needed information;
- missing navigational information (including on-premise signs);
- poor placement of signs (e.g., outside the cone of vision); and
- inadequate legibility distance, given traffic circumstances.

Signs are deficient if they do not provide needed information when and where it is needed. Signs that are missing, difficult to find, difficult to read, or provide too much, too little, or confusing information result in driver disorientation. Disoriented drivers are more likely to vary speed, brake excessively, encroach on lane lines, or miss exits or turns. Signs must have the conspicuity and size to be noticed and read where the information is needed, while at the same time recognizing the legitimate information needs of other driving tasks. Deficient signing is not a sign attribute, but a construct relating sign characteristics with driver needs determined by their motivation, expectancies, and visual ability. Hungry drivers are motivated to find food. Violated expectancies increase the importance and type of information needed. Drivers expecting an entrance in a certain location need a sign to tell them if it is or is not going to be there. Failure to provide this information is a signing deficiency.

All these hypotheses are accepted at face value and are not proved by any strong experimental foundation. This does not make them false, but it does serve notice that not much is known about the extent or conditions under which they are valid. In sum, we think all sides in the arguments over commercial signing have elements of truth in their positions. In other words, *in some circumstances*, commercial signs *do* distract, *sometimes* they *mask* more important information, and *sometimes* they *help* disoriented drivers find their way and drive more safely.

A THEORY OF DRIVER BEHAVIOR

In order to understand the interplay between commercial signing and traffic safety, one must understand the dynamics of driving. The highway literature is filled with accepted principles that can be used to infer a general theory relating signing and driver behavior. This information has provided researchers with a set of principles that can be employed in analytic tools to improve highway and traffic engineering. In particular, the theory described in this section was implicit in the development of the engineering practice called Positive Guidance (Alexander and Lunenfeld 1990). Positive Guidance was developed as a tool for traffic engineers to diagnose problems and propose solutions to improve safety and traffic operations at sites with identified safety problems, particularly problems related to the processing of highway information, including signs, by drivers. Positive Guidance attempts to improve the highway information system to match driver attributes and information demands. This chapter represents the first effort to apply the practice of Positive Guidance to commercial signing.

Driving and the Role of Primacy

Driver error results from excessive task demands, expectancy violations, too much or too little processing demand, or deficient information displays. There are three generic tasks in driving that can be described in terms of an ascending scale of task complexity and a descending scale of primacy (i.e., the relative importance of each task to safety).

1. ***Control:*** high in primacy; low in complexity
2. ***Guidance:*** medium in both primacy and complexity
3. ***Navigation:*** low in primacy; high in complexity

Control includes all activities (e.g., steering and speed control) involved in the driver's interaction with the vehicle and its controls and displays (e.g., the steering wheel and speedometer). Task performance ranges from relatively undemanding (passenger vehicle with automatic transmission and power steering) to relatively demanding (tractor-trailer with multiple gears and clutches). Information for this subtask comes primarily from the "feel" of the vehicle itself, from its displays, and from the roadway. Drivers continually make minute adjustments and use feedback to maintain control. While this is the most critical subtask (rated high in primacy), most control activities, once mastered, are performed "automatically" with little conscious effort (rated low in complexity). This situation can rapidly become more complex, such as when a vehicle loses stability on a slippery surface, experiences a tire blow-out, etc.

At the guidance level, the driver's main activities involve the maintenance of a safe speed and proper path relative to roadway and traffic elements (e.g., intersections, other vehicles, and work areas). Guidance activities are characterized by judgment, estimation, and prediction within a dynamic, constantly changing environment. Information is gathered from the highway and its appurtenances, traffic, and the highway's information system. Guidance-level decisions are translated into speed and path maneuvers in response to alignment, grade, delineation, hazards, traffic, and the environment.

The most complex subtask, navigation, refers to the execution of a trip from point of origin to destination. Trips may be planned in advance but may change in route (e.g., a driver suddenly gets hungry or the gas tank approaches empty). Most navigation consists of a pre-trip phase, when trips are planned and routes selected, and an in-trip phase, when the travel route is followed. Pre-trip information sources include maps and verbal instructions. In-trip information sources include landmarks, route guidance signs, street name signs, and on-premise signing. This subtask is most complex in that it requires integrating information from many sources and applying judgment.

The Hierarchy of Information Needs

The information needs of the driver mirror the three driving tasks of control, guidance, and navigation. Alexander and Lunenfeld (1990) point out that drivers are continually accepting information for all three subtasks. When information needs are competing, primacy dictates what information is needed most. For example, a driver stops looking for a place to eat when negotiating a sharp curve because control is higher in primacy than navigation. While it is true that failures in navigation are usually noncatastrophic (drivers become lost and delayed when navigation mistakes are made, but navigation failures generally have less impact on the system than control or guidance errors), navigational errors should not be dis-

ISSUES IN THE REGULATION OF COMMERCIAL ELECTRONIC VARIABLE-MESSAGE SIGNAGE (CEVMS)

By Jerry Wachtel

The Federal-Aid Highway Beautification Act of 1965 prohibited signs that used flashing, intermittent or moving lights, or animated or moving parts. In November 1978, the U.S. Congress amended the Act to allow on-premise signs, displays, and devices "including those which may be changed at reasonable internals by electronic process or remote control…and which provide public service information or advertise activities conducted on the property on which they are located."

Following the 1978 amendment, the Federal Highway Administration (FWHA) undertook a study about the safety and aesthetic impact of these signs, which came to be known as Commercial Electronic Variable-Message Signage (CEVMS). FHWA requested the study because Congress had left it to the agencies administering the law to conduct research that would refine the general criteria and specifications that Congress had set out for CEVMS use.

With regard to human factors and highway safety considerations, the report reached two principal conclusions, which are summarized below:

1. While some accident studies have reported a positive relationship between accidents, high driving-task demands, and the presence of roadside advertising, others have reached opposite conclusions. Because of the limitations of accident studies, the available evidence that can be drawn from them remains statistically insufficient to *support* or *refute* such a relationship. Some investigators, both prior and subsequent to the publication of the FHWA report, suggested that drivers are capable of exercising appropriate primacy by ignoring visual or other stimuli that are not essential to the driving task, such as CEVMS. Other research, however, including recent studies of driver distraction, indicates that drivers do not always engage in appropriate primacy behavior.

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2. The substantial flexibility of display possessed by CVEMS makes it possible to use such signs in ways that can attract drivers' attention at greater distances, hold their attention longer, and deliver a wider variety of information and image stimuli than is possible by the use of conventional advertising signs. Use of this potential by advertisers seeking to reach an audience of highway users may increase the risk of overloading a driver's capacity to process important safety information and, consequently, increase the likelihood of driver error, particularly under road and traffic conditions in which drivers may already be stressed. Although the nature of these risks has been recognized in the research literature, the authors of the FHWA study suggested that further research was needed to quantify and categorize it. Those studies have never been conducted to the best of our knowledge.

Proponents of CEVMS hold that such technology can be operated in a manner that is quite different from traditional flashing, animated, scintillating, or moving message signs. Indeed, the adoption of such technology for use in official highway signs supports this view. The fact remains, however, that CEVMS uses technology that *can* be operated in a manner that is distracting. Therefore, issues of sign operation, location, and use, rather than the existence of the technology per se needs to be addressed by the highway safety community.

Issues in regulating CEVMS are complex. The best information available at this juncture is in Appendix A to this PAS Report, which takes excerpts directly from the 1980 FHWA report. These excerpts define the issues that local government needs to examine before regulating CEVMS. Table 4 from that report, included in Appendix A, will be especially helpful in addressing issues related to traffic safety and the visual environment for CEVMS.

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missed since they may increase driving time and distance, increasing exposure to an accident. Traffic safety is usually defined in terms of accidents per million vehicle miles. Therefore, to the extent that signing deficiencies result in additional miles of driving, these deficiencies reduce safety.

Information-Decision-Action

Each of the three driving tasks (control, guidance and navigation) are referred to as "information-decision-action" tasks. Drivers receive information from numerous sources and use that with information they already have (e.g., experience, skills, expectancies, and trip plans) to make decisions and perform actions. Drivers often have overlapping information needs. For example, a driver would need to know the position of his or her car in the lane at the same time he or she was trying to find an entrance to a drug store. In order to make a safe turn into that driveway, the driver: searches the environment; detects, receives, and processes information; makes decisions; and performs control actions in a continual feedback process.

Many researchers have noted different levels of information processing, which include the following stages.

1. Visual attention
2. Stimulus recognition and comprehension
3. Response selection and decision making

Visual attention. Hughes and Cole (1984) conceptualized the information acquisition process as it relates to driving. Their conclusions are summarized here.

- The visual environment contains information that is transferred to the retina of the eye where it is transformed to a neural code and transferred to iconic memory.
- There is probably little loss of information in this process, and the loss that does occur is related to the limits of the observer's eyesight.
- Iconic memory decays rapidly, but it can be "read" by some form of central processor and the information "read" is then transferred to short-term memory where it is available for recall or for decision making. Short-term memory decays over a period of several seconds, and its contents tend to be obliterated by new incoming information.

The factors that determine whether an element of information in iconic memory will be transferred to short-term memory, and therefore will be part of a recall or decision-making process, are the sensory conspicuity of the element, its information content, and the informational needs of the observer. Besides the incoming data, the central processor also employs other cognitive processes of the observer, including long-term memory. All of these sources will bear on the strategy used to scan the contents of iconic memory and on the criteria for selection of particular elements of information contained in it for transfer to short-term memory.

With regard to visual stimuli, drivers are serial processors who handle one source of visual information at a time. Given the need to parallel process (handle several displays simultaneously) while driving, they compensate by "juggling" several information sources. Drivers integrate various activities and maintain an appreciation of a dynamic, changing environment by sampling information in short glances and shifting attention from one thing to another. They rely on judgment, experience, estimation, prediction, and memory to fill in the gaps, to share tasks, and to shed less important information. Expectancy, motivation, and conspicuity all play a role in determining what a driver will notice.

Of course, for drivers to find information useful, it must first be noticed. Of the different levels of information processing, the greatest amount of research appears to have focused on the attention skills of the driver and driver performance. Attentional factors include, but are not limited to, *the preattentive process*, *selective attention*, and *divided attention*. There is also the issue of what attracts attention when driving. Of special significance is the relationship between attention factors and the abilities of older drivers—a topic addressed in the paragraphs below on selective attention and divided attention.

In the *preattentive process*, a driver's attention is quickly directed to events occurring in the visual field, including those in peripheral vision. The size of the visual field has long been addressed by visual science. Sanders (1970) defined the "functional" field of view as the spatial area needed to perform a specific visual task. Ball and Owsley (1993) defined the useful field of view (UFOV) as the visual field in which information can be quickly acquired in a glance. UFOV relates the diameter of the visual field to the ability of a subject to detect, localize, and identify highly conspicuous targets in complex scenes. Unlike the functional field of view, the diameter of this field is not related to the sensitivity of the eye but to both the conspicuity of the target and the duration of the target's exposure.

Parasuraman and Nestor (1991) define *selective attention* as the ability to focus and shift attention among stimulus locations, features, and categories. On the relationship of accident rates to information-processing stages, they present evidence that the switching of visual selective attention has the greatest correlation with driving performance. Higher correlations between selective attention and self-reported accident rates were found for older adults, and the highest correlations were found when switching attention from one focus to another.

A literature review (Staplin et al. 1986) on selective attention shows disagreement among researchers on the relationship of selective attention to driver performance. Staplin et al. suggest that the findings from several studies point toward the presence of age-related deficits on selective attention tasks "only when the whole stimulus array must be processed in order to find the relevant stimuli." For example, if visual search is required to gain relevant information for the driving task, the slower speeds of information processing for older drivers may be apparent. However, not all driving tasks require visual search, and experienced older drivers may know where to focus their attention.

Since driving already requires that a driver be capable of *divided attention*, the relationship between divided attention deficits and performance is unclear. The effects of divided attention on the driving task appear to be most evident when the driving environment is highly complex or demanding. In such an environment, drivers might have difficulty "automatically" responding to a situation and may need a greater reliance on memory to process information.

Brouwer et al. (1991) found older adults to have a significantly decreased ability to divide their attention between two tasks of lane tracking and visual analysis when compared to young adult drivers. In the visual analysis task, the older drivers had significantly more errors even though the task was self-paced. Their findings appeared to indicate that older subjects "were less able to detect their errors or to adjust their speed," which may offer evidence on age-related accidents where older drivers misperceive situations or do not react appropriately.

As the population ages[3] and demographics change, these considerations will necessarily play a greater role in helping determine how commercial on-premise signs, as part of the navigational aids experienced by drivers, can be sited and designed. Further research about visual attention and older drivers may lead to more definitive guidelines about such placement and design.

As regards an underlying issue (namely, what attracts attention when driving), Hughes and Cole (1986) report that, half of the time, drivers fixate on things not related to driving. And, when asked to report what they see, drivers report that half of the objects they see are not related to driving. Where advertising appears, there is increased attention to advertising, but this increased attention to advertising *does not result* in less attention to driving-related objects. Instead, a driver decreases attention to other non-driving-related objects. Hughes and Cole report several studies that all show that drivers have from 30 percent to 50 percent spare capacity that can be devoted to objects not related to driving, such as on-premise signs.

While these studies seem to suggest that the distraction and masking hypotheses described at the beginning of this chapter are not a significant problem, they need to be replicated in this country because their findings might not be accurate for twenty-first century America. Even without additional research, common sense suggests that the amount of spare capacity available to process navigational information is a function of the road, the environment, and driver familiarity.

Stimulus recognition and comprehension. Stimulus recognition occurs in stages as incoming visual information is compared with stored memory and an object that is first detected becomes partially recognized, perhaps with respect to its color or shape or texture. Hughes and Cole (1986) suggest that information content and the informational needs of the observer play a critical role in attention. If the object is recognized as something that might satisfy the information needs of the driver, additional sensory input will be acquired as the driver gets closer and recognition is completed. Objects that are recognized but not understood are not likely to receive attention. On-premise signs that communicate the nature of the business early and quickly will enable interested drivers to attend to the secondary information on the sign as they approach. Other drivers will be able to disregard the sign and search for other information more relevant to their needs.

Expectancy also plays a role in stimulus recognition and comprehension. Alexander and Lunenfeld (1990) suggest that drivers assume that their destination, no matter how obscure, will be signed on the freeway. Likewise, when looking for a commercial establishment, drivers expect to see signs telling them where businesses are, if not directing them as they get near. It would be helpful if drivers could know in advance how the destination will be signed. This is one of the elements that makes well-established logos so valuable to both the general public and the business community.

Response selection and decision making. A study of the role of information processing in highway design and its effect on decision making (COMSIS 1995) noted that decision sight distance (DSD) is a key concept of highway design and is based on perception reaction time and maneuver time. Alexander and Lunenfeld (1975) defined DSD as "the distance at which a driver can detect a signal . . . recognize it . . . select appropriate speed and path, and perform the required action safely and efficiently." This definition clearly parallels the stages of information processing: visual search, recognition, evaluation, decision making, response selection, and response maneuver.

Response selection and decision making can be a more significant problem for older drivers. Perhaps contrary to the findings in Brouwer et al. (1991), Hildebrand and Wilson (1990) report that "when faced with a decision, elderly people opt for accuracy in making a choice rather than speed. Their performance is worse when faced with severe time constraint." The speed/accuracy tradeoff has been studied by many researchers, and it has generally been found that speed is associated with higher error rates. Overall, older subjects tend to reduce their response speed for the sake of accuracy when the task is self-paced. Thus, we should expect them to take more time to read the information from an on-premise sign.

In uncertain or complex driving situations with multiple alternatives, older drivers demonstrate slower responses as they attempt to integrate information to make an appropriate response selection. One aspect of the age-related slowing of information processing occurs when older drivers scan their immediate and working memory to access information for decision making. Researchers have found that older individuals scan memory less effectively than younger subjects. Memory scanning for action sequences and decision rules are an important component of driving, and slower scanning is an age-related effect that increases as driving complexity increases (Staplin and Fisk 1991).

Use of advance cues or response preparation appear to help older drivers with response selection and decision making. When preparation time allows longer stimulus exposure and longer intervals between stimuli, older drivers performed better with less slowness in response (Stelmach and Nahom 1992). In a study on left-turn intersection problems, Staplin and Fisk (1991) found that "cueing drivers with advanced notice of the decision rules through a redundant upstream posting of sign elements improved both accuracy and latency of young and older drivers' decisions."

In general, age differences in performance are greater at increased retinal eccentricities, indicating a loss of UFOV (the Useful Field of View) among older drivers. Ball and Owsley (1993) reported that the three components of age-related reduction of UFOV are attention deficits in (1) speed of visual processing, (2) decreased ability to divide attention, and (3) reduced selective attention or the decreased ability to localize targets. Both Shiner and Schieber (1991) and Ball, Sloane, Roenker, and Bruni (1993) have shown that restricted UFOV results in an increased probability of accidents, particularly at intersections. The reduction in UFOV and its associated attention deficits are not easily overcome. The AARP 55 ALIVE/Mature Driving program stresses ways that older drivers can minimize the effects of these problems. (The program is an 8-hour classroom refresher course for motorists age 50 and older who have years of driving experience.) Sign designers, business interests, and planners can also minimize the problems associated with restricted UFOV by following principles suggested elsewhere in this report, including reducing the density of information on a sign through simplifying sign design and increasing recognition distances to give older drivers more time to respond to a sign safely.

GENERAL PRINCIPLES OF HIGHWAY SIGNING

Before looking at the specifics of designing signs for legibility and conspicuity, it may be helpful to review some general guidelines for sign design for road users. Some general guidelines can be obtained from the Federal Highway Administration's *Manual on Uniform Traffic Control Devices* (hereinafter MUTCD). According to the FHWA web site (http://mutcd.fhwa.dot.gov/), "the MUTCD contains standards for traffic control devices that regulate, warn, and guide road users along the highways and byways in all 50 States. Traffic control devices are important because they optimize traffic performance, promote uniformity nationwide, and help improve safety by reducing the number and severity of traffic crashes." Other guidelines can be taken from the Positive Guidance engineering practice, which, as noted above, is based on principles that describe the relationship between highway information, including signs, and driver behavior. In both cases, the usefulness of these guidelines for our discussion about on-premise signs needs to be tempered with this acknowledgment; namely, these guidelines are primarily concerned with *highway* signage and will need to be revised and adapted when necessary for their application to on-premise signs.

Guidelines Based on Federal Sign Standards

The MUTCD addresses the requirements for a wide range of signs, including warning, regulatory, guidance, and Tourist-Oriented Directional Signs (TODS). The manual discusses sign shape, color, symbol and text, dimensions, and lettering. It also addresses standardization, uniformity, and the excessive use of signs. Although developed for highway signs, the criteria described in the MUTCD and supporting documents can be used to develop minimum size and proper placement guidelines for the design and installation of on-premise and other commercial signs.

Fulfill a need. The MUTCD requires that traffic signs fulfill a need, and it is important to recognize that all commercial signs, and particularly on-premise signs, also fulfill a need of drivers.

Command attention. Signs that command attention are safer as they increase the range of distance over which they may be read. Commanding attention does not mean the sign should have entertainment value (commercial signs should never compete with traffic control devices for attention), just that it can be noticed in time to be read where the information is needed. Remember, signs that fulfill a need require less conspicuity than other signs to be noticed.

Convey a clear simple message. Clear messages reduce the time to make decisions. Johnson and Cole (1976) conclude that, since reading a sign message requires a driver to remove his or her eyes from the road, the message should be as simple as possible, thus ensuring its rapid acquisition and minimizing the amount of time the driver must turn his or her eyes from events on the roadway. Additionally, simple messages may require fewer words, allowing larger letter size for a given sign face size, thereby increasing legibility and readability and reducing driver response time. Complicated messages may require very large signs, and excessive size may elicit conflict with citizens concerned about aesthetics. Finally, if a sign contains so much copy that it loses its information value (especially navigational value), requiring a driver to glance at it multiple times, conflicts may occur not only with control and guidance tasks, but also with the driver's attention to other on-premise signs that may have interest as well.

Give adequate time for proper response. Size and placement affect conspicuity, legibility, and readability, which, in turn affect the time that a driver has to read the sign and react safely to it. Site conditions play a major role in determining how much time is needed for a driver to have adequate time to respond to a sign. This issue is discussed in more detail below.

Command respect of road users. Drivers will respect signs if they meet the criteria described above because meeting those criteria will result in signs that meet the driver's expectations and fulfill the driver's need for information. Respect for signs gives users faith in the entire signing system, including on-premise, commercial signs.

Guidelines Based on the Positive Guidance System

The research findings about regulating attention, comprehension, response selection, and decision making are the basis for a number of general principles in the Positive Guidance approach to identifying information deficiencies.

Design for drivers and accommodate target groups. A sign system must meet the information needs of drivers and special groups like older drivers, truck drivers, non-English speaking, etc.

Be responsive to task demands. If the task demands that the driver look left, don't expect the driver to see your sign on the right. This requires proper site planning integrated with road geometry. Otherwise, provide advance information (e.g., an off-premise sign) to create proper expectancy. Traffic engineers use "Stop Ahead" and "Left Exit" signs to create expectancies.

Meet the driver's expectations for signage and avoid surprises. To avoid surprises, on-premise signing should make it clear where a business is and how to get there with a reasonable amount of advance notice. For example, a sign clearly indicating the distance to an entrance to a mall will help overcome problems caused by geometry and roadside design. Likewise, an off-premise sign should make it clear it is off-premises and that the business is somewhere else. Ambiguity will leave the driver bewildered and searching for the business.

Eliminate sources of information error and upgrade any deficient signing. The most obvious source of information error is a sign with incorrect information. A far more insidious source of information error is the absence of information needed to correct false impressions created by other highway features or expectancies. For example, a sign on the road may not provide the information that the business is to the rear of a shopping center and which entrance should be used. Or a group of signs may give the appearance that the businesses are adjacent to the sign when, in fact, access to them requires a turn at the next street and some additional wayfinding is warranted.

Avoid overload. The principles of primacy and avoiding overload are the reasons for numerous conflicts between traffic engineers, business interests, and sign regulators. The fact that advertising signs are sometimes placed where primacy suggests that they should not be placed is often the result of the restrictions on the placement of businesses in commercial districts where businesses benefit from proximity to one another but must also compete for attention. The design of the commercial district, including the design as it is affected by zoning regulations (e.g., setback, height, bulk, and landscaping regulations), is a factor in influencing the placement of signs. It is incumbent upon the urban planner, representatives of the business community, and traffic engineers to work together if overload is to be avoided and traffic safety enhanced.

Devices that have the potential to overload the driver include:

- moving or dynamic displays that may hold a driver's attention until the dynamic is concluded;

- changeable message signs that use a number of displays in sequence, making it difficult for the driver to know when the sequence is ended and not stressing the most relevant information; and
- signs with so much navigational information that the driving tasks of control and guidance are affected negatively.

Devices that are less likely to overload the driver include:

- signs that contain information that has nothing to do with navigation or guidance, such as a telephone number or address, which are likely to be ignored unless a driver is seeking it;
- coded information that can assist drivers in knowing what information is irrelevant to them (e.g., prices at gas stations are unlikely to be noticed unless a driver wants to buy gas); and
- information presented in small type may readily be discarded when the primary message is very legible (e.g., “Smith’s Floral Shop” should be readable but secondary information, like “a dozen roses for $12,” might be presented in small type that most drivers would ignore if they had no interest in purchasing flowers).

Apply primacy when information competes. On-premise signing should recognize the natural primacy of information affecting control (i.e., the driver’s interaction with the vehicle and its controls and displays) and guidance (i.e., the driver’s maintenance of a safe speed and proper path relative to roadway and traffic elements) and not attempt to interfere with the selective attention that primacy invokes. This principle requires cooperation and not finger pointing. While the driver can sometimes be expected to apply primacy when determining what information should be attended to, the number of signs and the amount of information on them may create information overload in some locations. It needs to be recognized, however, that sometimes traffic signs have less importance to the driver than an on-premise sign. Therefore, reducing the number of signs does not necessarily mean reducing only the number of commercial signs. It may mean removal of some unnecessary highway signs as well.

TOWARD AN EFFECTIVE AND SAFE SIGN SYSTEM

The principles articulated in both the Manual on Uniform Traffic Control Devices (MUTCD) and the Positive Guidance system make it possible to suggest some guidelines for the placement and design of on-premise, commercial signs. The following sections offer some observations and recommendations about sign density, information density, sign visibility, and sign design

Sign Density

Other than a general admonition against too many signs, the MUTCD does not offer any specific guidelines on sign density. Clearly, there should be fewer signs where vehicle operators may be overloaded with information from all roadside sources. As an example, consider that Johnson and Cole (1976) concluded that “such loading may occur in merging situations or at interchanges or within decision distances from formal traffic sign displays that present complex information and decisions to operators.”

Planners could benefit from guidelines pertaining to the spacing of information on the highway. A number of techniques are available that may be used to limit the effects of sign density, including minimum spacing requirements and grouping signs for adjacent businesses on a single sign structure.

Spreading. Lower primacy information should be moved upstream or downstream to avoid conflicts with higher primacy information. The principle of spreading can be applied to on-premise signs in one of two ways. With new construction, care should be given to place entrances to shopping plazas so that on-premise signs do not interfere with higher primacy information. For example, entrances to business activity should be located as far from intersections and ramps as possible. Second, larger text can be used to move recognition of the most important information further upstream, and smaller text can be used to move less critical information downstream.

Coding. The use of graphics and icons reduces reading time and effectively increases the information processing capacity of the driver. Color and shape coding may be used to increase cognitive conspicuity (viz., conspicuity related to the information content of the sign and the psychological state of the observer) so that information density may be increased. While every sign cannot have the recognition of the Golden Arches, it is often possible to use a symbol of the service or product being offered to aid driver recognition and recall. For example, use of a symbol on an entry or exit sign for a parking lot to a franchise would be more conspicuous and deliver more information than the enter or exit sign alone. Maintaining sign space limits but using that space to deliver more conspicuous and more informative "copy" through coding could simultaneously benefit community aesthetics, business activity, and traffic safety.

Repetition. When possible there should be continuity of signing from billboards, Tourist-Oriented Directional Signs, and other advance signing to the on-premise sign and the specific business. A graphic on an advanced sign can help a driver better recognize sign content when that graphic is repeated on an on-premise sign.

Redundancy. Use redundancy to make certain that signs are visible to drivers from each approach or to reduce the chance of blocking or masking. A projecting sign is designed to be seen from upstream, from downstream, or across the street. For businesses that are setback from the street, a sign on the street and a high mounted sign over the building may be effective in helping the driver more easily find the business.

Information Density per Sign

In general, the more information on a sign, the greater the potential for the sign to distract drivers from other signs and highway information. This being said, there is no conclusive evidence that signs with more information are more distracting. Still, less copy on a sign permits more white space, which researchers believe increases drivers' attention or sign conspicuity. The United States Sign Council is currently funding research by The Pennsylvania State University to consider the benefits to business success of more empty space on signs. Empty space generally should result in less secondary copy. Empty space may also mean more aesthetically pleasing signs. This research may yield the first of many examples of how the interests of business, traffic engineers, the public, and planners may come together.

While more empty space and less secondary copy may best serve the needs of some businesses, other businesses may need to provide more secondary copy on their signs. This is not necessarily a problem for drivers since, as noted earlier, drivers filter out information that is not relevant to their needs. However it is easier for drivers to filter nonrelevant information if the primary navigational information is made highly legible. Therefore, secondary, nonnavigational information should not be the same size as the primary navigational message.

Signs that clearly and quickly identify the type of business allow drivers to ignore secondary information if they are not interested. In this case, a driver would need more than a quick glance at this sign to know that the business is selling ice cream.

Douglas Mace

The name of the business is clearly displayed on this sign, but only at the same legibility as all the secondary advertising copy. Although drivers can filter out nonessential information (in this case, the secondary ad copy), signage is more effective when the navigational information (in this case the Burger King logo) is larger than the non-navigational information ("Treat Yourself . . .").

Douglas Mace

There are two issues here; one issue is to get the navigational information large enough to satisfy the information needs of motorists, the other is to find ways to code secondary information so that it is less distracting to drivers. The two issues are related. Signs that clearly and quickly identify the type of business allow drivers to ignore secondary information if they have no interest in that type of business. This should reduce the potential of unnecessary distraction. Gas stations and motels are two examples of businesses that quickly communicate their identity to drivers—gas stations because we are familiar with their names and logos; motels because the word motel is only five letters that is usually made highly legible.

In areas with high overload and information conflicts, the information density of the primary navigational message should be limited to a single glance. A simple message (i.e., one with few characters or elements) can be made larger, which allows it to be seen further upstream, possibly removing the recognition time from the area where the driver is heavily loaded. A simple message that a driver can recognize in a single glance consists of, at most, six words. Zwahlen (1989) deter-

Secondary information (e.g., the gas prices) presented in positive contrast (light against dark) is less likely to be noticed, thus drawing the driver's attention above to the primary message needed for navigation.

Douglas Mace

mined that two seconds was the maximum amount of time a driver could take his eyes off the road and look at the dashboard without losing lateral control of the vehicle. This might be extended to three or even four seconds if the sign is in the cone of vision, allowing the driver to see the road in the periphery with some detail. Various reading time models (Mitchell and Forbes 1943, and Odescalchi et al. 1962) suggest that a driver can read anywhere from 1.5 to 3 words per second. Therefore, the primary navigational information (e.g., the description of the business) should be limited to a maximum of six words. In a separate analysis, Kuhn et al. (1998) suggested a maximum limit of five words. In general, large signs should be used to make information more visible and not just to increase the amount of information presented.

The sign in the photo at the top of page 28 is an example where the driver is forced to read all the text before finding out that the business sells ice cream. Unless familiar with "The Meadows," the driver looking for a particular type of business will have to make repeated glances at the sign until close enough to read the entire sign contents (i.e., all the secondary copy). This will consume the driver's time that could be devoted to the acquisition of other information. What makes a sign like this even worse is that, when the words "Ice Cream" are finally legible, the sign is probably outside the cone of vision, forcing the driver to take his eyes off the road. In this case the sign has taken a disproportionate amount of the driver's time, which could have been given to other on-premise signs, created an unsafe situation, and resulted in the loss of some business because some drivers will give up trying to read the sign and place their attention elsewhere.

The sign in in the middle photo on the opposite page clearly names the business but only at the same distance that all the secondary copy is legible. Depending on the approach speed, increasing the size of this sign so that the business was identified further upstream could benefit both the business and the driver. While everyone might benefit from increasing the size of the business name, the size of the secondary copy should not be increased. That way, drivers not interested in Burger King can easily ignore the secondary copy, and the potential distraction of the sign is reduced.

While it is best to have the primary navigational information visible upstream and recognized quickly, other methods of coding may also be effective. The sign in the photo at the bottom of the opposite page shows how information placed underneath in positive contrast (light against dark) is less likely to be noticed, which effectively draws the motorist's attention to the most critical navigational information. With effective coding methods, the secondary information is less likely to distract drivers or mask more important information. Forbes (1939) found that signs on top in a group had the highest priority value; that is, they were seen first and best. Others might argue that it is the white space surrounding the place name that draws attention. Certainly the gas prices appear to be less conspicuous. More research is needed to quantify the effect of these techniques on the driver's capacity to filter information.

Sign Visibility

Assuming that a commercial sign is providing a clear and simple message that is relevant to a driver's need for information and that the other issues (e.g., sign density) discussed above have been considered, sign regulators and business owners need to develop effective regulations for ensuring sign visibility. These issues include sign placement and sign design, which determines the conspicuity, legibility, and readability of the signs.

Sign placement that promotes visibility and readability. As objects move into the periphery of a person's field of vision, their images become less clear and eventually they are not seen at all. With respect to traffic signs, the first concern is that they not be placed outside the cone of vision where drivers may not notice them at all or may not be able to find signs they are looking for. The MUTCD requires signs to be placed so that they appear in the cone of vision. According to the American Association of State Highway Transportation Officials (AASHTO) (1994):

> Speed reduces the visual field, restricts peripheral vision, and limits the time available to receive and process information. Highways built to high design standards help compensate for these limitations by simplifying control and guidance activities, by aiding drivers with appropriate information, by placing this information in the cone of clear vision, by eliminating much of the need for peripheral vision, and by simplifying the decisions required and spacing them further apart to decrease information processing demands.

With respect to signs that are not in the cone of vision, the concern is not only that drivers may miss the sign, but that drivers will try to read these signs, forcing their eyes to leave the road to focus on the sign. When this happens, the road must be viewed peripherally, which creates an unsafe situation. It is in the interest of traffic safety that commercial signs providing necessary navigational information be placed in the cone of vision. Line of sight for commercial signs is essential to minimize conflict with public directional/informational or guidance/control signs that have higher primacy. Signs that must be read at large angles to the line of sight on the road risk not being read or result in unsafe driving behavior. Either the driver will skip the sign or have a very poor vision of the road while reading the sign. For the purpose of minimizing driver overload and improving traffic safety, placing on-premise signs in the cone of vision to the extent possible given factors such as building orientation, required setbacks, and roadway width, is equally as important as providing sufficient legibility.

There is no clear rule as to exactly what boundaries define the cone of vision. Pignataro (1973) regarded the most acute vision to be within a cone of 3 to 5 degrees and the limit of "fairly clear sight" to be within a cone of 10 or at most 12 degrees. Beyond this limit, vision becomes blurred. While peripheral vision determines the horizontal angle at which a driver can read a sign, the vertical angle is determined by the attenuation from the windshield, normally 5 to 7 degrees. In general, signs that can be seen only at horizontal angles greater than 10 degrees and vertical angles greater than 5 to 7 degrees are considered "out of view" for normal driver eye tracking of the road.

Garvey et al. (1996) provided the sign setback and mounting height requirements necessary to maintain a sign within this field of view. These specifications are a function of the required viewing distance, which is a function of speed. Table 2-1 provides the recommendations from their paper.

Placing an on-premise sign in the cone of vision and maximizing its legibility and recognition distance serves not only the interests of traffic safety, but the interests of business and the community as well. Drivers who did not notice or could not find the on-premise sign when it was placed outside the cone of vision will have a greater likelihood of seeing the sign when it is within the cone of vision. Assuming adequate conspicuity and legibility of the sign, and the business's ability to satisfy the needs of some drivers, the volume of business should increase and the likelihood of business failure should be reduced.

Table 2-1 suggests that the faster the speed, the longer the Minimum Required Legibility Distance (MRLD), and the longer the MRLD, the greater the setback and mounting height. While the data provided by Garvey et al. (1996) are useful as a frame of reference, there are several problems with their assumptions that must be considered.

First, in computing MRLD, they do not consider that drivers may need additional time and distance if they need to make a lane change or slow down to turn into a business. This would not make much difference at low speeds because their assumptions are generous, but more distance may be needed at higher speeds.

Second, while MRLD is the minimum required distance, there is no reason longer distances can't be used to increase setback and mounting height. A larger sign that can be read further away may be set back further. This assumes, however, that there is a line of sight to the sign. Buildings, trucks, or other signs will often prevent a line of sight to a large offset so that this advantage for large signs is not realized. Still, larger signs may be needed for adequate letter size, even if larger setbacks are not possible because of sight distance. Also, even if sight distance makes large setbacks and tall mounting heights possible, smaller setbacks and heights may be desirable because they make the sign readable over a greater distance.

Finally, the use of MRLD does not consider extra visibility distance to allow drivers time to notice the sign and begin to read it. Sign conspicuity may require a sign to be noticed (not the same as being recognized) further away than MRLD. The relationship between conspicuity, letter size, and MRLD is discussed in more detail below.

TABLE 2-1. THE RELATIONSHIP BETWEEN VEHICLE SPEED, LEGIBILITY DISTANCE, SETBACK, AND HEIGHT

Vehicle Speed		MRLD*	Setback	Mounting Height
in MPH	in feet per second	(in feet)	(in feet)	(in feet)
55	81	440	77	39
50	73	400	70	35
45	66	360	63	32
40	59	320	56	28
35	51	280	49	25
30	44	240	42	21
25	37	200	35	18

*MRLD is the minimum required legibility distance or the recommended distance at which a sign should be readable. Further discussion of MRLD is provided below in the section on sign design.

Source: Garvey et al. (1996)

When a sign is placed within the cone of vision, other factors can still affect its ability to be seen, recognized, and understood. Those factors are *angular presentation* (the viewing angle of the sign from perpendicular to the line of sight) and the sign's *surround*. Surround is the term used to describe the area around the sign viewed from the location where the sign should be detected. It is to be distinguished from the sign background, which normally refers to the area of the sign against which the letters are read. Therefore the background of a Stop sign is red, its surround is determined by whatever is in the visual field around the sign. The contrast of a sign with its surround determines detection, while the contrast of the letters and background determine legibility.

A sign may be mounted within the cone of vision but still be presented to the driver with a large *angular presentation*. Conspicuity is reduced by the visual distortion of the sign shape. Legibility will also be reduced because of distortion in the apparent shape of the letters. Garvey et al. (1996) recommend keeping this angle at less than 20 degrees. Also, for signs that are not internally illuminated, large viewing angles prevent headlights from effectively illuminating retroreflective signs. Replacing a wall sign with a projecting sign, for instance, might be one way of improving a sign's angular presentation.

Mace et al. (1982) found that, as visual complexity is increased, the effects of contrast with the *surround* are reduced. Visual complexity is multidimensional; namely, it is affected by the number of light sources, level of visual detail, and the demands placed on the driver. Signs will be more readily seen if placed to have maximum external contrast (meaning the luminance of the sign compared with the luminance of the area immediately surrounding the sign) in an area with low visual complexity.

Sign design that promotes visibility. The focus of this section will be on principles for designing signs to improve the visibility of on-premise and other commercial signing to promote safe wayfinding. Most of these principles are the same as those that govern all highway signs. Issues of sign design relate to many of the principles already discussed and have been summarized by several authors (see Schwab 1998 or Garvey et al.1996).

Mace et al. (1986) developed an analytic framework for evaluating the adequacy of any sign. The framework reflects the principles of supply and demand, and is based upon the simple observation that drivers need a minimum amount of time, and therefore distance, to process and respond to information. The supply of information refers to the sign design characteristics that provide conspicuity and legibility. Colors, materials, illumination and font, and letter size, for example, all have an impact on conspicuity and legibility. The most universal measure of this is detection and recognition distance; however, reaction time is also often used as an evaluation criterion. In general, it is the design of the sign, together with the method of lighting and its placement on the road that determines how much distance and, therefore, time that must be supplied to the driver.

The Minimum Required Visibility Distance (MRVD) model for estimating the minimum detection and legibility distances that drivers require incorporates the findings of numerous studies to make an estimate of the distance requirements for sign legibility and conspicuity (Paniati and Mace 1993). MRVD is a generic term to refer to both MRDD (minimum required detection distance) and MRLD (minimum required legibility distance). MRDD includes MRLD, but adds additional time and, therefore, distance to allow a sign to be noticed. It is assumed in this model that, depending on the type of sign, the driver may need time for some or all of the following: detect a sign, comprehend its message, make a decision, initiate a response, and implement or complete a vehicle maneuver (such as a lane change or deceleration) before reaching the sign.[4]

The following sections are directed at methods to increase the conspicuity and recognition of signs.

Conspicuity. A conspicuous object, according to Cole and Jenkins (1978) is one that will, for any given background, be seen with certainty probability ($p>.9$) within a short observation time ($t<.25$ s) regardless of the location of the target with respect to the line of sight. Hughes and Cole (1986) cite the work of Engel (1976), who drew attention to the sensory conspicuity of an object, which depends upon the prominence of its physical properties compared with its background, and cognitive conspicuity, which he saw as dependent on the information content of the sign and the psychological state of the observer. Mace and Pollack (1983) made a similar observation when they suggested that the conspicuity of a sign depends upon the motivation and expectancy of the driver, so that Stop signs following "Stop Ahead" warning signs are more conspicuous, as are all signs at intersections compared with those midblock. This is why Cole and Hughes (1986) found that the conspicuity of an object depended upon the instructions given to an observer, and this is why we have difficulty generalizing the results of previous research beyond the specific group of subjects and the instructions they were given.

Hughes and Cole (1984) discussed two kinds of conspicuity: *attention conspicuity*, which is the capacity of the target to attract attention when the observer's attention is not directed to its likelihood of occurrence, and *search, cognitive,* or *conspicuity*, which was defined as the accessibility of the target when the observer was explicitly directed to look for the object. Signs with advertising as their primary purpose seem to require attention conspicuity, and billboards, because of their size and location, are more likely to gain attention. Wayfaring signs seem suited to search conspicuity. Smiley et al. (1998) found that subjects' recall of the types of facilities listed on signs was poor except for the name they were explicitly instructed to search for. The data collected by Hughes and Cole (1986) suggest that traffic control devices are considerably less conspicuous in shopping center environments than on other types of roads and less conspicuous on arterial roads than on residential roads. Cole and Hughes (1984) argue that visual clutter is the most likely explanation for reduced attention conspicuity and not the added demands of the driving task.

Attention (sensory) conspicuity is determined by the physical prominence of an object's properties compared with its surround. It may be improved by an increase in the brightness of a sign or its contrast with its surround. Placing the sign in a less visually complex surround helps. The internal layout or graphic quality of a sign may also be a determinant of conspicuity. Just as white space gains attention in a newspaper, signs that have blank space are more easily noticed. Blank space may be obtained by making signs larger or by removing secondary copy that has no navigational value. A research study is currently being conducted by the Pennsylvania State University on the effectiveness of white space surrounding the text of on-premise signs.

Cognitive (search) conspicuity is dependent on the information content of the sign and the psychological state of the observer. Hungry drivers are more likely to notice restaurant signs. The more useful the information on the sign, the more likely it will be noticed. If drivers are looking for your business by name, then the name is important. If drivers are looking for your business by the type of product or service, then product or service name is most important. While basic research would suggest that sign conspicuity is greater if the sign has a distinctive shape compared with other signs, there has not been much research of this in a road environment. Distinctive shapes can yield recognition as is the case with the Stop and Yield signs and many commercial signs.

Some of the variables that affect attention conspicuity are discussed below.

Display message content. A number of researchers have speculated that the graphic content of a sign affects both conspicuity and recognition. Jenkins (1981) writes that one of the factors that affects conspicuity is "information content of the object including information arising from the unusual or unexpected character of the object." He further writes that the "exogenous control of visual selection will be primarily influenced by the design of the sign, its size, reflectivity, bold legend, and the background in which it is placed." Please note that Jenkins is referring to reflectivity as it relates to highway signs; "luminosity" would be the equivalent concern for on-premise signs. Hughes and Cole (1986) cite converging evidence that the bold internal graphics of symbolic signs contribute usefully to their conspicuity. Taken together, these references suggest that it may be possible to increase the conspicuity and/or recognition of signs by adding icons to the text. When the graphics used are not familiar and are not likely to become familiar through frequent encounters, the legibility of text may still have to be relied upon.

Beyond graphic content, other factors that can influence conspicuity and recognition include the border, color, shape, and size of a sign.

Border. A dark border around a light colored sign and a light border around a dark colored sign can aid conspicuity, particularly when the surround does not contrast well with the sign.

*Color***.** The evidence suggests that conspicuity is improved by both luminance and color contrast; however, as long as color contrast is maintained, there does not appear to be any advantage for any one color. Legibility can be mediated through either color or luminance contrast (Morales 1987). Cole and Jenkins (1978) and Mace (1983) found that white signs were detected less easily at night than signs of color. During daylight, signs of dark color are generally more noticeable because the backgrounds are normally light. At night, the reverse is likely to be true. The reader is advised that the relationship between color and conspicuity is a complex one. We recommend seeking the advice of an experienced professional sign designer and consulting the most recent traffic engineering research before making any regulation related to the use of color on signs.

Shape. Basic research suggests that sign conspicuity is greater if the sign has a distinctive shape compared with other signs. Distinctive shapes can increase recognition distance as is the case with the Stop and Yield signs or McDonald's golden arches.

Sign Size. The size of a sign affects its conspicuity as well as the size, spacing, and layout of message content. With respect to conspicuity, size can be minimized by attending to the issues of surround and luminance. The need for large on-premise signs may also be reduced by making effective use of symbols or by transferring some of the information to off-premise signing.

Legibility and Recognition

Legibility refers to the ability of the eye to clearly distinguish individual characters and numbers in an alphanumeric message. It is generally described in terms of visual acuity, which ranges from about 20/17 (young drivers) to 20/40, the minimum required for licensing. Recognition or readability refers to the ability of an observer to understand the meaning of an alphanumeric or graphic message. Words are often recognized without total legibility because of familiarity with the length of the word or the pattern of letters. Even when reading alphanumeric signs, recognition often results without legibility because, in any font, not all letters are equally legible. Some letters in the alphabet might have only half the legibility distance of other letters.

Factors that relate to recognition and legibility have been studied far more than the issue of conspicuity, and there is a large body of literature that addresses these issues. (See Garvey et al. (1996) for an annotated bibliography.) Of all the factors that affect legibility, the visual acuity of the observer, the font, and font size are the most critical. Other factors, such as spacing, contrast, background, luminance, and the use of lower case have an effect, but nowhere near as great an effect as font and size. With regard to alphanumeric text, the required size depends on the required legibility distance, the acuity of the observer, and the font used.

Forbes and Holmes (1939) used the legibility index (LI) to describe the relative legibility of different letter styles (fonts) used on highway signs. The LI is the distance in feet at which a one-inch letter is legible for individuals with a specific level of visual acuity. LI changes as acuity changes. Multiplying the LI by the letter height in inches tells you the distance in feet at which a word or letter should be legible.

The legibility of a verbal message or recognition of symbols requires that the visual system resolve the critical detail of the key elements of the sign message content. The MRLD model may be used to determine either the required detection or legibility distance or the required LI for a sign based upon the required distance and the available letter height. The LI is important to the determination of the required size for a sign in a specific application. Mace (1988) noted the following relationships:

Required letter size = MRLD / LI

or

Required LI = MRLD / letter size

Either the letter size or the LI may be manipulated to satisfy the MRLD requirement. For any observer, LI is determined primarily by the font. While other factors, such as letter spacing and contrast have some effect, from the standpoint of sign maintenance, spacing and contrast cannot be expected to compensate for inadequate letter size. Therefore it is important to determine the required size at the time of sign installation. However, contrast and luminance will have an effect on the LI; therefore, the required letter size may depend on the method of illumination as well as other factors that determine legibility (e.g., letter spacing and the use of lower and upper case). Signs of adequate size should be installed so that daytime legibility is maintained and the luminance requirements for nighttime recognition are realistic.

Letter size. The formula above is an oversimplification in that it assumes that letter size is proportional to legibility distance and that the LI of a particular font remains constant over distance. Mace and Garvey (1993) show that beyond certain distances, which were shorter for older drivers, proportional increases in legibility distance did not occur under conditions of retroreflective sign illumination. The effect, which may be optical or atmospheric, has not been well quantified, and is generally inconsequential inside 500 feet. For long distances, a little extra letter size may be necessary. With other types of sign lighting, the effect may be quite different and further research is needed.

Still, as noted above, to determine the required letter size one needs to know the MRLD and the LI, which will depend on the font used and the acuity of the observer.

Several attempts have been made to determine the MRLD. The *Traffic Control Devices Handbook* (U.S. DOT 1983) assumes a minimum legibility distance of four seconds for an acceptable sign. The research by Garvey et al. (1996) assumed 5.5 seconds as the minimum requirement. A computer model that estimates a unique time and distance for most signs in the MUTCD was described by Paniati and Mace (1992). This approach allows the MRLD requirement to reflect differences in the amount of legend on a sign, the complexity of the decision the sign requires, and, most important, whether the driver needs to slow down or change lanes before reaching the sign. In a recent report to the American Association of State Highway and Transportation Officials (AASHTO), McGee and Mace (2000) recommended two sets of generic values based upon the MRLD computer model. One set was to meet the MRLD requirements of signs requiring some maneuver before the sign, the other set requiring no maneuver.[5] Table 2-2 shows the MRLD for 4 seconds, 5.5 seconds, and the values recommended by McGee and Mace.

The 5.5-second values from Garvey et al. (1996) give lower values than the MRLD with maneuver from McGee and Mace (2000). Compared with the MRLD without maneuver from McGee and Mace, the values using either 4 or 5.5 seconds are very generous.

It should be noted that the values in the table are minimum values for most signs in most situations. Signs requiring greater legibility distance include:

- signs grouped in a cluster where there are several signs that must be read;
- signs that have more than six words to be read; and
- signs with a message that is not readily understood.

Acuity of observer. Given an MRLD, one still needs to know the LI of the font being used in order to determine the letter size needed. The LI of a font is dependent not only on the font, but the visual acuity of the observer. The LI for younger drivers with good visual acuity is much greater than the LI for older drivers. Also, the LI is 10 to 20 percent less at night than during daylight.

Under daytime conditions, highway series B, C, and D letters were reported to have an LI of 33, 42.5, and 50 feet per inch of letter height (Forbes and Holmes 1939). To find the legibility distance for these LI ratings, multiply the LI by the letter height (in inches); for instance, a sign using 10-inch-high letters for the D series, which have an LI of 50, would be legible at 500 feet and closer for a daytime driver with 20/40 vision. Forbes et al. (1950) found the wider, series E letters to have an index of 55. Over time, the value of 50 feet per inch of letter height has become a nominative, though arbitrary and disputed, standard. While these LIs may be reasonable for younger drivers, the LI of the series D letters for older drivers is closer to 40 and may be as low as 30 for some drivers.

Garvey et al. (1996) and Schwab (1998) based their recommendations for required letter height on drivers with the poorest (20/40) vision who still receive driver's licenses in most states. They also assumed that the font being used was equal to the visibility of the fonts used on highway signs. If we assume the use of a highway font, or equivalent, and an older driver with 20/40 vision just acceptable for a drivers license, the appropriate LI as used by these authors is 30. With this assumption, a 12-inch letter is legible at 360 feet and closer.

TABLE 2-2. MINIMUM REQUIRED LEGIBILITY DISTANCES IN VARYING SITUATIONS

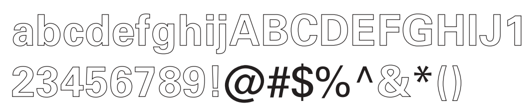
Speed MPH	MRLD @ 4 seconds (in feet)	MRLD @ 5.5 seconds (in feet)	MRLD @ with manuever (in feet)	MRLD @ without manuever (in feet)
25-30	175	225	410	155
35–40	235	325	550	185
45–50	290	405	680	220
55–60	350	485	720	265
>65	385	525	720	280

A reasonable alternative would be to target drivers with 20/30 vision, which represents about 90 percent of the population and an even greater percentage of drivers. While not proven (another research need), drivers with the worst vision are assumed to adjust their driving behavior to match their abilities and are also more likely to know where they are going and not rely on signs. In our opinion, the cost to accommodate every driver is too great and probably would not be met. It is far better to use the 20/30 criteria and seriously attempt to meet the requirements of most drivers. The series D font would have an LI of 40 for drivers with 20/30 acuity and a 12-inch letter would provide them with 480 feet of legibility. Please note that the use of 30 as the LI of a highway font is a gross but conservative generalization. The different series of highway fonts have different LIs. And remember, LI is higher during daylight and is further increased by driver familiarity with the word.

Font. In addition to acuity, font is the other major factor in determining the legibility of a sign. The legibility of the font is best expressed by its legibility index (LI) for a driver with a specified acuity. This should be considered the reference LI for the font. As discussed below, other factors such as contrast and spacing can prevent a font from achieving its reference LI.

The research on the legibility of different fonts at long distances has been primarily funded by the government and limited by its desire to maximize legibility and to avoid artistic presentations and fonts with serifs. Kuhn et al. (1998) concluded that while an extensive font choice allows for creative designs, it creates problems for sign designers because there is virtually no legibility distance data for the vast range of fonts used in advertising signing.

While trying to obtain funding to perform this critical research for the on-premise sign industry, researchers at the Pennsylvania State University have begun the work (Zineddin, Garvey, and Pietrucha, under review). Using eye charts like the familiar Snellen chart, they have determined, for example, that the font displayed in the accompanying graphic has less than half the legibility of the highway series E font. Therefore, to have your sign readable at 400 feet will require a 20-inch letter with this font, where a 10-inch series E font would be readable at the same distance.



A font example with less than half the legibility of the highway series E font.

The design of on-premise signs must recognize that stylized fonts may be acceptable for pedestrian traffic, but some of these fonts severely reduce legibility for highway traffic.

Other factors affecting legibility. Other variables that will reduce the reference LI of a font are briefly summarized below.

Internal contrast and sign luminance. The luminance contrast of a letter against its background is necessary to accommodate the visual acuity of all drivers. While minimum luminance and contrast are necessary, excessive contrast created by too bright a background will reduce legibility. (Readers interested in the issue of luminance and contrast are encouraged to consult the *IES Sign Lighting Handbook*, 8th edition.) A minimum contrast ratio of 4:1 is recommended and 50:1 is considered too great (Mace et al. 1994).

Spacing of letters. Crowding letters reduces legibility. The spacing of letters following the MUTCD guidelines is recommended for all signs. While minimum spacing will allow a font to achieve its reference LI, this LI will not be increased by wider spacing (Mace et al. 1994).

Use mixed-case letters. Use of mixed-case letters does not provide consistently greater legibility (Mace et al. 1994) but may create recognition of a business name, product, or service before the words are legible. This is primarily effective with names and words with which drivers have familiarity and that have an identifiable pattern in word length or the number of ascenders or decenders. Garvey et al. (1997) indicate the height of mixed-case letters may be reduced about 10 percent for equivalent recognition distance.

Contrast orientation. Positive contrast signs (light text on a dark background) are easier to read than negative contrast signs (dark text on a light background). The use of positive contrast may increase the LI of a font up to 30 percent.

Orientation of text. Horizontal text is easier to read then vertical text.

COOPERATIVE TRIANGULATION

Although additional research will certainly be beneficial, there is an abundance of information from which a design guide for quality commercial signs can be developed. Still, it will be difficult to fully implement these principles without the cooperative effort of all the stakeholders and other interested parties. The primary stakeholders include traffic engineers, business owners, sign manufacturers, city planners, elected officials, neighborhood and environmental groups, financial institutions and consultants, and learning and behavioral experts.

The interests of these and other groups seem to be focused on three issues: traffic safety, aesthetic achievement, and economic success. Cooperative triangulation is a method by which these stakeholders can find solutions that can result in success with regard to all three criteria. Firth (Transportation Research Circular, under review) reports success with this approach in his experience developing wayfinding systems in Pennsylvania.

Visual acuity of observers, font, and font size are the most critical factors affecting sign recognition and legibility. Other factors such as contrast, sign spacing, background, luminance, and use of upper and lower case letters also have an effect. Shown below are two similarly situated signs with stark differences in legibility.

A road map to achieve cooperative triangulation would be a project unto itself; however, a few first thoughts here may be helpful to initiate the process. First, the ways that each stakeholder can help the others must be identified. For example, Tourist-Oriented Directional signing is an effort by highway agencies to aid navigation to businesses. Another step highway agencies could take is to enforce more self-discipline in the installation of unnecessary highway signs, particularly unnecessary changeable message signs (CMS), or lengthy CMS messages.

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City planners need to understand the significance of primacy and how it relates to zoning and access to business and parking lots, and how good planning and well-designed on-premise signs can add to the economic vitality and aesthetic quality of their community. A traffic engineering study, which looks at driver overload in the area and the required decision sight distance for on-premise information, should be part of each new business construction plan. An important part of this plan will be the recognition that adequate sign size that enhances conspicuity, legibility, and readability is important to business vitality and traffic safety.

Given traffic engineering input concerning where drivers should safely receive navigation information and an assumption that the necessary content will be six or fewer elements, an appropriate legibility distance can be determined. Given information regarding minimum required legibility distance and an assumption about the expected LI of the font to be used, a community could develop some guidelines about appropriate sign size. While maximum size could be regulated, the use of traffic engineering data would establish some guidelines about minimum size and height. The goal would be to develop a set of recommendations resulting in a sign system that would help motorists receive the information they need or want within sufficient time and distance.

While there is not a simple solution as to how these ideas may be implemented, this chapter, together with an opening dialogue among the stakeholders, could result in more communication and cooperative participation. A similar initiative was suggested by Cannon (1999), who urged "city planners and other municipal officials to work in creative collaboration with sign users and sign designers." He believes the result will be "a community in which the quality-of-life indicators would always be rising." Cannon sets out two goals: the need for retail merchants "to survive and succeed, producing prodigious tax revenues for the city" and for commercial signs to "visually unify the commercial areas, and at the very least, improve the appearance of commercial streets." He goes on to point out that "measurable success requires an honest equilibrium between the needs of all stakeholders." It is important to invite the traffic engineering community to join in this collaboration and see that the third leg of cooperative triangulation (traffic safety) is added to the common ground that everyone should be trying to perfect. There is nothing to be gained by ignoring the traffic safety problem and have city planners and sign users work alone.

NOTES

1. This discussion is concerned only with signs intended to be seen and read by drivers of moving vehicles and is not intended to be applied to signs intended only for pedestrians. We recognize that there are many commercial areas that are not automobile-oriented and that changes in demographics and planning policy may be increasing the number of commercial areas that are pedestrian-oriented. The expertise of the author, however, and the importance of this issue in crafting legal and effective regulation for signs led to an editorial decision to limit the discussion to traffic-oriented signs.

2. Some courts have, in fact, rejected these hypotheses because of a lack of evidence. Planners must, therefore, be extremely careful in crafting any sign regulation that would be based *solely* on the issue of traffic safety. Traffic safety is a legitimate purpose for sign regulations and should be addressed. There are legitimate prohibitions on signage that do not run afoul of First Amendment protections. For example, restrictions on advertising signs that have lighting, color, or movement that could make it more difficult to detect a sign that affects traffic safety (e.g., a flashing sign located in the same area of vision as a traffic light) can be regulated or prohibited. Readers of this report should review the chapter on legal considerations in drafting regulations and must consult their municipal attorney before attempting to write effective and legally defensible

regulations related to commercial signage and traffic safety. This chapter provides an understanding of how the principles that foster safety also serve the interests of business and the community. This information will not only serve to develop regulations that benefit everyone, but to encourage the voluntary development of better signage within the boundaries of regulations.

3. This section's focus on older drivers is consistent with the evolving concern of transportation officials with the diminishing capacities of an aging population whose demand for mobility has increased their rate of exposure in highway traffic. While there is a gradual deterioration of vision throughout life, visual deterioration generally becomes significant about the age of 50. It will be seen that older drivers not only need more time and therefore distance to access information from signs, but losses in visual capacity result in older drivers needing larger signs just to provide the identical time and distance that a younger driver would need for recognition of information. The concept of a legibility index is discussed in the chapter as the practical method by which the signing needs of older drivers can be met.

4. The Minimum Required Visibility Distance (MRVD) for older drivers may be considerably longer than for younger drivers because of diminished abilities to recognize and process information and to execute lane-changing maneuvers. Without reference to MRVD, one might think that the special needs of older drivers for conspicuity and legibility are based solely on visual impairment. The concept of MRVD makes it obvious that factors such as reaction time, decision making, and problem solving increase the distance needed by the older driver to detect and read signs, and that these factors can create visibility problems for the older driver even when visual impairment is not considered. In general, older drivers not only have problems seeing what younger drivers can see at a given distance, but they also need to recognize and be able to read signs at greater distances to provide them with the additional time they need to respond in a safe manner.

5. McGee and Mace have a third set of values for symbol signs not requiring a maneuver, but these values, which are higher, only apply for retroreflective signs being illuminated solely by headlamps.

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