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An Evaluation of Exit Symbol Visibility

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
National Engineering Laboratory
Center for Building Technology
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Final Report

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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, *Secretary*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

ABSTRACT

The performance of exit symbols was assessed in a laboratory experiment using viewing conditions degraded to resemble smoke. Research participants were presented with color slides showing symbol signs designed to be used in buildings. For each slide the participant indicated if the symbol conveyed the message of "exit". A total of 108 symbol slides were used, of which 18 were exit symbols. Each of the 42 participants were familiarized with a random set of 9 of the 18 exit symbols, prior to data collection. During the experiment, the symbol slides were presented under three levels of viewing difficulty. In general, errors increased as the viewing conditions became more degraded but the increase in errors became much more severe for some symbols than others. Fewer errors were made for some of the symbols that had been familiarized. The data suggested that increased errors under degraded viewing conditions were related to graphic features of the symbols. A number of specific symbol features that influence exit symbol effectiveness were identified along with features of non-exit symbols that produce confusions. Finally, recommendations for exit symbol design are presented that may lessen egress-related confusions during emergency evacuation.

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1. INTRODUCTION

Systems of pictorial signs are increasingly used to replace or supplement traditional written messages. These pictorial signs have a number of advantages in addition to the obvious virtue of communicating to the foreign speaking or functionally illiterate (Collins, 1982). In many public, industrial, and transportation facilities, messages related to egress such as "exit" and "no exit" provide the most fundamental information for public safety. Nonetheless, there is little agreement on how information regarding exits should be graphically portrayed or symbolized. Many symbolic versions of the "exit" message have been developed, including efforts by various international and national standards groups and government agencies. Yet in only a few cases has there been a formal evaluation of the effectiveness of various individual symbols. Furthermore, the increasingly wide variety of images used to convey information symbolically also contributes to confusion. Figure 1 shows a few proposed exit symbols; some further examples may be found in Lerner (1981). The diversity of graphic approaches illustrates the lack of common agreement on imagery for depicting exit (see Lerner and Collins, 1980) as well as the need to evaluate the effectiveness of different images for the exit message.

Two factors are critical in evaluating a pictogram for "exit." One factor is how well the symbol is understood by those who encounter it. This factor has been emphasized in several previous NBS publications (Collins and Pierman, 1979; Lerner and Collins, 1980; Collins, Lerner, and Pierman, 1982). The second factor is how visible[1] the symbol remains under potential emergency conditions where viewing may occur under degraded conditions involving smoke, reduced illumination, and so forth. A limited body of research has compared different graphic images for understandability under good viewing conditions while another, smaller, body has compared their visibility under degraded viewing. The present research focuses on the intersection of the understandability and visibility problems: that is, how effectively do various symbols communicate the message of "exit" when viewing conditions are seriously degraded?

1.1 UNDERSTANDABILITY CONSIDERATIONS

Several studies conducted at the National Bureau of Standards have evaluated the understandability of safety symbols, including some providing egress-related messages. While detailed results are discussed in the original reports (Collins and Pierman, 1979; Lerner and Collins, 1980; Lerner, 1981; Collins, Lerner, and Pierman, 1982; Collins, 1982), several important conclusions regarding egress messages are summarized below.

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[1] Visibility is defined by the Illuminating Engineering Society (IES) (1972, p. 1-21) as, "The quality or state of being perceivable by the eye...." "In indoor applications it is usually defined in terms of the contrast or size of a standard test object observed under standardized viewing conditions, having the same threshold as the given object."

Figure 1. Exit symbols proposed for use

In an initial evaluation of exit symbols proposed by the International Organization for Standardization, (ISO) TC21 (1978), Collins and Pierman (1979) determined that the originally proposed "exit" symbol was correctly defined by only 25 percent of the participants, while the percentage of correct definitions for the "no exit" symbol was even lower (3 percent). This latter symbol also elicited answers related to exit or safe haven from some 35 percent of those tested. Figure 1 includes the symbols studied in the research summarized in section 1.1.

In an experimental assessment of different evaluation methodologies, Lerner and Collins (1980) included three "exit" and two "no exit" symbols. The proposed ISO image, showing a person and an open door was correctly understood by some 70-85 percent of those studied (as compared with 22-60 percent for the original ISO "exit"). The third "exit" symbol, showing a figure, arrow and fire, was correctly identified by 85-95 percent. The two "no exit" symbols, ISO original and ISO proposed, were correctly identified by only 7-30 percent, and 33-70 percent, respectively. (Subjects received no special training on exit symbols in these studies.) These data indicate a wide range in the comprehension of different graphic approaches for symbolizing egress messages. Two other experiments, Collins, Lerner, and Pierman (1982) and Collins (in preparation) also determined that the understandability of additional images for "exit" and "no exit" differed substantially in terms of percentage correct identification. While the results varied somewhat, depending on the procedure and population studied, the poorest symbols were understood by fewer than 25 percent of the participants, while the best approached 100 percent understandability.

Lerner and Collins (1980) also determined that no strong stereotypical image existed for the major egress concepts. When people were given an opportunity to sketch their own ideas for an "exit" symbol, many subjects had difficulty in producing any image at all, with little agreement among those images produced. These data suggest that the level of consensus that exists on the essential graphic elements for messages such as "fire extinguisher" and "no smoking," does not exist for the message "exit."

The NBS studies on symbol comprehension also revealed that a number of ambiguous symbols not only failed to communicate their intended meaning but also elicited critical confusions in meaning. For example, somewhat abstract symbols indicating firefighting equipment or direction were interpreted as indicating egress by substantial numbers of participants. More importantly, some symbols designed to indicate "not an exit" were given the opposite interpretation. Such critical confusions could easily lead a sign user in a totally inappropriate direction during a building emergency.

The large percentages of incorrect responses to some exit symbols, the lack of a common image stereotype for exit messages, and the number of critical confusions elicited by some exit and no exit symbols, underscore the need to evaluate the effectiveness of egress symbols. Despite the problems noted for egress symbols, symbols, in general, have been shown to be an effective means of communicating information. When compared with word signs, selected symbols have been demonstrated to be perceived more rapidly (Janda and Volk, 1934),

more accurately (Walker, Nicolay, and Stearns, 1965), and at a greater distance (Smith and Weir, 1978), even under distracting conditions.

Such advantages are clearly desirable for egress symbols, where emergency conditions could reinforce the need for rapid and accurate understanding of information on signs. As a result, the present investigation was undertaken to assess the relative effectiveness of 18 egress symbols under adverse viewing conditions similar to those which might occur during a fire or similar building emergency.

1.2 VISIBILITY CONSIDERATIONS

As noted earlier the success of an egress symbol depends not only upon good understandability, but also upon clear legibility, particularly during emergency conditions. Smoke poses a major threat to life during fires, since problems of perception in smoke which disrupt escape usually precede the thermal and toxic effects of the fire (Gross, Loftus, and Robertson, 1966). The disorienting effects of smoke, fear, lachrymation, and possibly even confusion due to interference with the central nervous system by some noxious smoke products (Phillips, 1978) can further compound the problem of seeing the correct way out of a smoke-filled building. This potential disruption emphasizes the importance of egress signage during emergencies. In addition, smoke obscuration can cause special problems for viewing signs: since smoke density increases with distance above the floor, obscuration may be greater at the typical location of such signs (such as above a door) than toward the floor (Demaree, 1979). Automatic sprinkler systems can drastically influence the pattern of smoke as well. Tests of simulated hospital room fires reveal that the initiation of sprinklers can divert the flow of gases from a burning room to a corridor from hot gases passing through the top of the doorway to cooler gases passing through the bottom of the doorway (O'Neill, Hayes, and Zile, 1980). This rapidly results in a relatively uniform ceiling-to-floor obscuration in the adjacent corridor. Thus, while sprinklers may be an effective means of fire containment, they may also augment visibility problems. The increased use of automatic sprinkler systems therefore should not lead to less concern with exit sign visibility.

Although the visibility of signs in smoke has been researched, the focus of interest has generally been either on smoke parameters, such as composition and density, or on hardware parameters, such as illumination source and intensity or reflectivity (Demaree, 1979; Bono and Breed, 1965; Jin, 1970). Almost no research has focused specifically on the visibility of symbolic imagery on signs in building environments. Some reports have compared the visibility of symbols with word signs for highway applications (Jacobs, Johnston, and Cole, 1975; Dewar and Ells, 1974; Dewar and Swanson, 1972). Although the symbols generally were more visible than the written messages, these experiments used distances much too long and presentation times too brief to represent realistic conditions for people in buildings, however appropriate for highway users. One study which did compare exit symbols in smoke (Japanese proposal, 1980) found a 35 percent difference in the range at which the symbols were visible. Unfortunately, the translated discussion of this Japanese research does not provide any methodological detail.

An additional complication in considering visibility and understandability is that these factors may not be independent. In general, the exit symbols found to be most understandable tended to be literal depictions of walking or running figures, doors, and flames in various degrees of realism and detail. At the other extreme, highly abstract, simple images were much less well understood. Although understandability and visibility data for the same set of exit symbols are not available, it can be hypothesized that the detailed, well-understood symbols will in general be less visible than the bold and simple, but more ambiguous, symbols. This hypothesis underscores the importance of considering both understandability and visibility in designing and testing exit symbols. Using only one criterion could produce a symbol which is deficient on the other factor.

1.3 VISIBILITY: METHODOLOGICAL CONCERNS

In evaluating how well a symbol communicates when visibility is reduced, two methodological factors demand special consideration. These are: the response required of the viewer; and the means of manipulating the viewing conditions to degrade visibility.

Most research that has compared the visibility of various symbols (usually for highway applications) has used a limited set of symbols, in which the subject indicates which of a known set of images has been presented on a given trial. A primary problem with this procedure is that it may be described as a discrimination experiment, in which the participant must decide which of several known images is presented. Thus, the findings may reflect how well symbols within a known set can be discriminated from one another, rather than how well any individual symbol can be identified when encountered alone in the environment. To determine which stimulus of a specific set was presented, the participant may rely on minor irrelevant cues which effectively distinguish one symbol in the set from another one. These cues may be unrelated to the features which are actually used to recognize a symbol encountered in a real environment. For example, Zwaga (1979) compared two methods for determining the legibility of public information symbols proposed by ISO. In one procedure, participants were familiarized with the set of symbols, and on each trial indicated which symbol of this set was presented. In the other procedure, participants were unfamiliar with what they were to see, and their task was to describe what was presented. Very different results were obtained with the two methods. The same symbol was not necessarily best under both procedures, and the procedure in which participants were familiar with the symbols consistently yielded much higher visibility estimates. Perhaps most critically, Zwaga reported that for "familiar" participants, legibility was related to the uniqueness of subsets of symbol features. Thus, the flaws in this general procedure are that "visibility" is strongly determined by exhaustive knowledge of all the symbols included in the evaluation. Furthermore, the subject's perceptual task may not be a good approximation to the real-life situation.

The alternative of using a totally unfamiliar set of symbols, with no prior exposure, has its own disadvantages. First, visibility is confounded with understandability. It would be difficult to determine whether a subject indicated that a symbol was not visible because he/she could not see it or

simply because he/she did not know what it meant. Secondly, if a limited set of symbols is tested, the symbols will become more familiar with repeated presentations; thus, familiarity may change through the course of an experimental session, and the previously identified problem of reliance on a subset of cues can arise.

Presenting each symbol only once may overcome this problem but may be so inefficient a procedure as to be impractical. Thus, whether the subject identifies a particular symbol from a known set or attempts to interpret an unfamiliar symbol can have a major effect on the results, and neither method may be entirely appropriate. The resolution of this methodological problem for the present experiment is discussed in section 2.

The other major methodological concern is the way in which viewing conditions are degraded. Experiments evaluating symbols (usually for highway applications) have manipulated perceptability in a number of ways: by severely constraining viewing time (Markowitz, Dietrich, Lees, and Farman, 1968); reducing brightness contrast (Smith and Weir, 1978); restricting the visual angle subtended by reducing size or increasing distance (Mackett-Stout and Dewar, 1981); blurring the stimulus image (Smith and Weir, 1978); introducing smoke (Japanese proposal, 1980); or stressing subjects by demands for speed or performance of additional tasks (Testin and Dewar, 1981). If these various manipulations produced equivalent results, choosing one method would simply be a matter of methodological convenience. However, there is evidence that the relative visibility of two symbols may vary depending on the specific viewing conditions.

Although explicit experimental comparisions are not common, results from different experimental approaches can be compared. Thus, where two viewing conditions are employed in an experiment, the correlation coefficient for the response measures under the two conditions can be calculated. If the relative visibility of the symbols in a set is similar under both conditions, the correlation will be high. Table 1 presents the correlation coefficients, as presented by the authors or as calculated from published data, for six experiments. The comparison viewing conditions are listed as well. Table I indicates that the correlations tend to be only moderate. Two values are presented for the experiment described in the Japanese proposal (1980); because the obtained value of $r=0.83$ is due to one extreme data point. With this point omitted, the correlation is essentially zero. The relatively low correlations given in table 1 may reflect changes in procedure confounded with changes in the visibility condition, or a relatively large error variance relative to the difference between symbols. In addition, there may be interactions with the response measure. These findings suggest that any discussion of symbol visibility must include reference to the actual physical and response parameters varied.

These findings raise two important points. First, any assessment of symbol visibility should provide a reasonable simulation of the actual viewing conditions of interest, since results may not generalize well. Secondly, any theories or empirical generalizations attempting to explain or predict relative visibility must be able to account for the effect of the specific method for degrading perception. More extensive empirical data would certainly be useful

in indicating the extent to which a theory of symbol visibility must include specific viewing conditions.

Table 1. Correlation of Symbol Performance Under Multiple Viewing Conditions

Experiment	Viewing Conditions	Correlation
Mackett-Stout and Dewar (1981)	Distance vs. duration	r = 0.25
Smith and Weir (1978)	Blur vs. glare	r = 0.49
Jacobs et al. (1975)	Maximal blur vs. no blur	r = 0.53
Testin and Dewar (1981)	Distance vs. various loading tasks	r's from 0.34 to 0.73
Ells and Dewar (1979)	Glare, darkness vs. good viewing	r = 0.82
Japanese proposal (1980)	Smoke vs. no smoke	r = 0.83 (r = -0.11 if symbol 1* is omitted)

2. EXPERIMENTAL APPROACH

In the present experiment, the performance of various exit symbols was studied under conditions intended to simulate emergency viewing under reduced visibility. The physical parameters of the viewing condition were designed to simulate the problems of reduced illuminance and increased light scatter typical of smokefilled environments. The response conditions were designed to model the problem of determining whether a given symbol does, in fact, indicate "exit" or a different message. The graphic features of exit symbols were varied to determine their relative visibility under different viewing conditions.

The effects of smoke reduce visibility by lowering target luminance, and increasing scattered light, which reduces overall contrast (Middleton, 1952). In the present experiment, these effects were simulated, according to the method employed by Lerner (1981), by using neutral density filters to reduce target luminance and by adding a veiling luminance to reduce contrast.

Choice of an appropriate response task involved consideration of both the effects of familiarity noted in section 1.3 and the need to simulate decision problems faced by persons during a fire. In a fire a person's main objective is to locate and use the nearest exit. An individual is confronted with the problem of deciding whether each sign encountered is presenting exit information or not. Under these circumstances, a person would not normally have detailed knowledge of the entire set of signs present in the building, and certainly could not be expected to have explicit experience in discriminating them. Thus, the task becomes one of encountering a sign, familiar or unfamiliar, and determining whether it might be an exit sign. While a person might have some preconceived ideas about what such signs might look like, he/she could not assume that a specific exit image is present, particularly given the present lack of standardization.

In an attempt to simulate such considerations for the present experiment, the subject's response task was to view a large set of symbol signs and decide whether each sign was or was not an exit sign. These symbol signs portrayed a variety of messages typically encountered in buildings and workplaces. Only one-third of the symbols were actually intended to mean "exit". The subject responded "yes" if he/she thought the symbol was an "exit" message and "no" if not. Adequate viewing time was provided to avoid producing spurious effects of temporal factors.

The other parameter of special note is viewing distance (or correspondingly, image size). Several studies have determined visibility by obtaining the distance at which symbols are recognized under "good" or "normal" viewing conditions; a number of these experiments specifically addressed symbols for building use. While the authors typically emphasized the differences between symbols, perhaps the overlooked finding is that visibility under good viewing conditions may not be a critical concern. Virtually all the symbols tested may be adequate under these conditions. To determine typical reported viewing distances, the results of the experiments on building symbols were transformed, using the relationship, tangent visual angle = size/distance, to determine at what distance a 12 in (30.5 cm) sign could be recognized. Jin's (Japanese proposal,

1980) results for exit signs indicate distances of about 48 to 92 m (about 150 to 300 ft). Mackett-Stout and Dewar's data (1981) for public information signs indicate distances of about 60 to 150 m (about 200 to 500 ft). Zwaga's (1979) recognition data for public information symbols indicate a distance of at least 105 m (about 345 ft). These distances are all large relative to most building spaces, especially given code requirements for distances to exits. For example, Sharry (1978, p. 111) has summarized the maximum permissible distance to exits (for new construction) prescribed in the Life Safety Code. For public and industrial settings, these range from 75 to 150 ft (22.9 to 45.7 m) for various unsprinklered occupancies, and from 75 to 200 ft (22.9 to 61.0 m) for sprinklered occupancies (greater distances are permitted in certain low risk storage and business occupancies). Because symbols appear to be detectable at a greater distance than that required for travel to an exit, they will generally be adequately visible under ideal viewing conditions. But given the often poor correspondence between relative visibility measures obtained under different and degraded viewing conditions, it may be unwarranted to generalize the relative performance under normal building conditions to poor visibility conditions. The present experiment therefore attempted to use a realistic visual angle for the stimulus, and more representative visual conditions. The subtended visual angle of 1.3° is equivalent to viewing a 30 cm (12 in) sign at 13.4 m (44 ft), while the stimulus presentation procedure simulated emergency lighting and smoke.

In addition, to deal with the problem of familiarity, each subject was familiarized with a randomly selected subset of 9 of the 18 exit symbols prior to beginning the experiment. This provided a general familiarity with the kind of symbol signs that might be encountered. However, since neither the full set of exit symbols, nor any of the non-exit symbols, were viewed in advance, subjects were not able to learn a subset of graphic cues that could be used to discriminate exit symbols from other messages. Thus, during the experiment they presumably had to rely on interpreting each symbol, rather than simply locating some known graphic feature.

The performance measure obtained for a given symbol is determined both by how effectively its imagery conveys the message of "exit", and by how conspicuous its elements remain when viewing conditions are degraded. Poor performance could reflect either poor understandability or poor visibility. The pre-familiarization of a set of exit symbols for each subject allowed these two factors to be discriminated to some extent. A large difference in performance between those subjects familiarized with a symbol and those not familiarized with it indicates that low understandability is contributing to poor performance. On the other hand, if familiarization has no effect on performance, the symbol must be successfully communicating its message without prior familiarization. Similarly, a symbol which is correctly identified under "normal" viewing conditions, but not under "poor" viewing conditions can be said to have poor "visibility". In this way the effects of understandability and of visibility can be somewhat separated.

Because subjects could also err by interpreting an unrelated message as "exit", the present procedure provided additional information about egress-related confusions through the use of foil or non-egress symbols. The sign features or

messages of the foil symbols which most often caused confusion with exits could then be identified. These features could then be eliminated from exit symbols so that possible serious errors under true emergencies would be anticipated, and corrected.

The experiment had as its major goals the following:

(a) To compare proposed exit symbols for their effectiveness in communicating the appropriate message under emergency conditions, particularly under dim, smoke-filled circumstances.

(b) To identify the relative contributions of visibility and understandability factors for particular exit symbols.

(c) To identify some general features of successful exit symbols.

(d) To identify features of non-exit symbols that might cause them to be misinterpreted as exit indicators.

3. METHOD

3.1 SUBJECTS

The subjects were 42 volunteers, 14 males and 28 females, ranging age from 18 to 53 years (mean age=27.3). They were recruited from the Gaithersburg, MD, area through local advertising and paid for their participation. All reported normal or corrected-to-normal vision. Corrective lenses were worn by those who normally wore them.

3.2 SYMBOLS

One-hundred-twenty-six different symbols were presented. Each symbol was originally drawn as a 30.4 cm x 30.4 cm (12 in x 12 in) placard, and then photographed against a medium grey background for presentation in slide form. Eighteen of the symbols were intended to convey the messages of "exit" or "emergency exit." The other 108 foil symbols depicted a wide range of other messages, the only common feature being that all were messages that might be seen in or around buildings. The symbols were selected (with modifications in some instances) from adopted or proposed standards, commercially produced signs, and symbols used for various public facilities or events. The 18 exit symbols, and the sources from which they were taken, are shown in figure 2; the remaining foil symbols are shown in appendix A.

Luminance measurements were taken for each of the various colors that appeared in the slides, so that brightness contrasts for the various color combinations occurring could be calculated. The approximate ratios of the luminances, averaged over several measurements, were: red/white: 1/8; green/white: 1/8; blue/white: 1/11; black/yellow: 1/28; black/white: 1/35. An exception to these measures was for exit symbols N through R, which had been drawn at a different time than the other symbols. These black and white slides had a brightness ratio of about 1/80. Thus, the contrast can be calculated as about 0.97 for the black and white slides; 0.91 for blue and white; 0.88 for red or green and white; and 0.96 for yellow and black.

3.3 SYMBOL LISTS

Three separate presentation lists of 54 symbols were constructed. Each list consisted of 18 exit symbols, together with 36 non-exit, or "foil", symbols. The 108 foil symbols were initially divided into 36 triads on the basis of similarity of meaning and appearance; one member of each triad was then assigned to each list. The order of the 54 slides in a list was randomized with the following constraints: the first two and last two items of each list were foils; exit symbols could not occur more than three times in succession (in fact they never actually occurred more than twice in succession); foil stimuli could not occur more than five times in succession.

3.4 APPARATUS

The stimulus slides were viewed through the binocular eyepiece of a three-channel projection tachistoscope. One channel was always illuminated, so that a

Figure 2. Exit symbols tested in the present experiment

constant dim field was visible. This procedure provided a veiling illumination when the stimulus slide was simultaneously presented, resulting in reduced brightness contrast in the viewed symbol. The veiling field also served to maintain a relatively constant luminance level, so that no significant change in brightness occurred when the symbol slide was presented.

To create low luminance levels deliberately, all symbols were projected through a neutral density filter. By inserting different filters, the luminance (brightness) of the stimulus slide could be changed. Thus, the image viewed by the subject was of a symbol first reduced in brightness by the filter and then optically combined with a veiling light to reduce contrast. The resulting image was a dim, "washed out" symbol, which simulated the light-attenuating and scattering effects of smoke.

As presented during the experiment, the projected image of the symbol subtended a visual angle of 1.3 degrees. The luminance of the veiling light was approximately 1.0 cd/m^2. Since this value was roughly an order of magnitude greater than the luminance of the symbol slide, the total luminance did not change substantially when the slide image was added to the veiling light. The symbol slides were projected through one of three neutral density filters, which had nominal values of 2.7, 3.0, and 3.3 log units. The resulting luminances, for a white slide image as viewed through the eyepiece and measured with the veiling channel turned off, were 0.085, 0.060, and 0.032 cd/m^2, respectively. This resulted in three viewing conditions (which represented a range of easy to difficult task performance based on pilot research).

3.5 SEQUENCES OF LISTS AND VIEWING CONDITIONS

The three presentation lists were each shown in forward and reverse orders, effectively yielding six sequences. Each participant viewed each sequence once. The participant saw all three lists in one direction before being presented with any of the lists in the opposite direction (direction of first lists counterbalanced across participants). A given viewing condition remained in effect for an entire list. Each viewing condition (determined by the choice of the neutral density filter) occurred once during the first three lists and once during the final three lists.

Across subjects, each viewing condition occurred an equal number of times at each of the six list positions. Each filter/list combination occurred an equal number of times as well.

3.6 PROCEDURE

After reading instructions that outlined the general nature of the experiment (appendix B), the participant was shown a random set of nine of the eighteen exit symbols for familiarization. The symbols were in placard form, and the participant was free to spend as much time as needed to become familiar with them. Next, more detailed instructions (appendix B) were presented which stressed the importance of making a best guess for every slide, even when the decision was very difficult. After five minutes of visual adaptation to the dim level of room illumination used during data collection, a sample slide was

shown, using the brightest of the three viewing conditions. This familiarized the participant with the appearance of the stimuli and the operation of the response key.

Presentation of the stimuli was controlled by the participant. When a telegraph key located near the tachistoscope was pressed, a red dot appeared, which served as a ready signal. After 1 second the ready signal terminated and the symbol slide was presented for 4 seconds. The participant indicated "yes" or "no" on an answer sheet to indicate whether or not the symbol shown conveyed the message of "exit". After recording an answer, the participant pressed the key to initiate a new trial with the next slide. After an entire list of 54 slides was completed, the subject had a brief rest period during which the experimenter changed both the slide set and viewing condition. An entire experimental session of six presentation lists took less than 90 minutes.

4. RESULTS AND DISCUSSION

4.1 EXIT SYMBOL DATA - OVERVIEW

Table 2 presents the percentage of errors, or failures to identify a symbol as an exit, for each of the 18 exit symbols. The data for each symbol are presented for each of three viewing conditions and for the average of the three viewing conditions. Data for subjects familiarized and not familiarized with each symbol are also presented in table 2. Each listed value is based on 21 subjects making two observations. A total of 126 observations were made per symbol, across all three viewing conditions for each familiarity condition.

Figure 3 portrays the information from table 2 graphically. Open circles depict data for unfamiliarized subjects while filled circles depict data for familiarized subjects. Line segments connect the values for the two groups of subjects. Figure 3 also shows estimated standard error bands for various percentages of incorrect responses. These standard error estimates are based on the normal approximation to the binominal distribution, with the approximation $S_e = \sqrt{NPQ}/N \times 100$ percent (where N = number of observations; P = proportion of correct responses; Q = proportion of incorrect responses).

The data on the response to the symbols can be discussed in at least four different ways. These include the responses to: the viewing condition; familiarization; specific graphic characteristics of the symbols; and the foil stimuli. While the different experimental manipulations can be identified separately, it should be noted that their effects interact in many cases. Separating the effects of the different experimental manipulations is difficult, due to the overall interaction between visibility and understandability. Nevertheless, the following general results are apparent.

First, increasing the difficulty of seeing by decreasing slide luminance (increasing filter density) increases the number of errors, for both familiarized and unfamiliarized symbols. Secondly, providing initial familiarization decreases the number of errors. Thirdly, the effects of viewing condition and familiarity vary widely with the graphic features of the symbols studied. In general, the symbols with a greater number of details (more graphic elements) tend to have higher error rates for both familiar and unfamiliar conditions, particularly for the poorest viewing conditions. The most abstract symbols appeared to benefit most from familiarization. Fourthly, a number of the foil symbols elicit exit-related confusions. Other results will be discussed in detail in the following sections, including the graphic elements of foil stimulus related to exit confusions.

4.2 VIEWING CONDITIONS

The overall effect of varying the viewing condition was to increase the numbers of errors made under the poorest viewing condition, regardless of familiarization. Under the most favorable viewing condition, all exit symbols (which had been familiarized) produced error rates under ten percent, except for symbol Q. Thus, with the exception of Q, the performance of viewers for these symbols is not statistically discriminable. The high proportion of

Table 2. Percentage of Errors for Each Symbol and Viewing Condition

Exit Symbol	Visibility Condition (Neutral Density Filter Value, Log Units)							
	2.7		3.0		3.3		All Conditions	
	Familiar	Unfamiliar	Familiar	Unfamiliar	Familiar	Unfamiliar	Familiar	Unfamiliar
A	7.1	83.3	7.1	83.3	19.0	81.0	11.1	82.5
B	9.5	33.3	9.5	23.8	35.7	54.8	18.3	37.3
C	7.1	9.5	7.1	11.9	26.2	28.6	13.5	16.7
D	2.4	0.0	2.4	2.4	26.2	26.2	10.3	9.5
E	0.0	2.4	2.4	2.4	28.6	33.3	10.3	12.7
F	9.5	0.0	16.7	2.4	33.3	23.8	19.8	8.7
G	4.8	14.3	4.8	31.0	59.5	71.4	23.0	38.9
H	2.4	11.9	4.8	21.4	64.3	81.0	23.8	38.1
I	9.5	45.2	11.9	35.7	14.3	38.1	11.9	39.7
J	2.4	0.0	0.0	4.8	31.0	50.0	11.1	18.3
K	0.0	0.0	2.4	0.0	19.0	19.0	7.1	6.3
L	4.8	2.4	0.0	7.1	42.9	28.6	15.9	12.7
M	2.4	2.4	7.1	4.8	33.3	40.5	14.3	15.9
N	0.0	0.0	4.8	2.4	19.0	28.6	7.9	10.3
O	0.0	2.4	0.0	0.0	31.0	28.6	10.3	10.3
P	0.0	4.8	0.0	4.8	23.8	33.3	7.9	14.3
Q	16.7	11.9	33.3	26.2	90.5	88.1	46.8	42.1
R	2.4	4.8	16.7	14.3	81.0	88.1	33.3	35.7

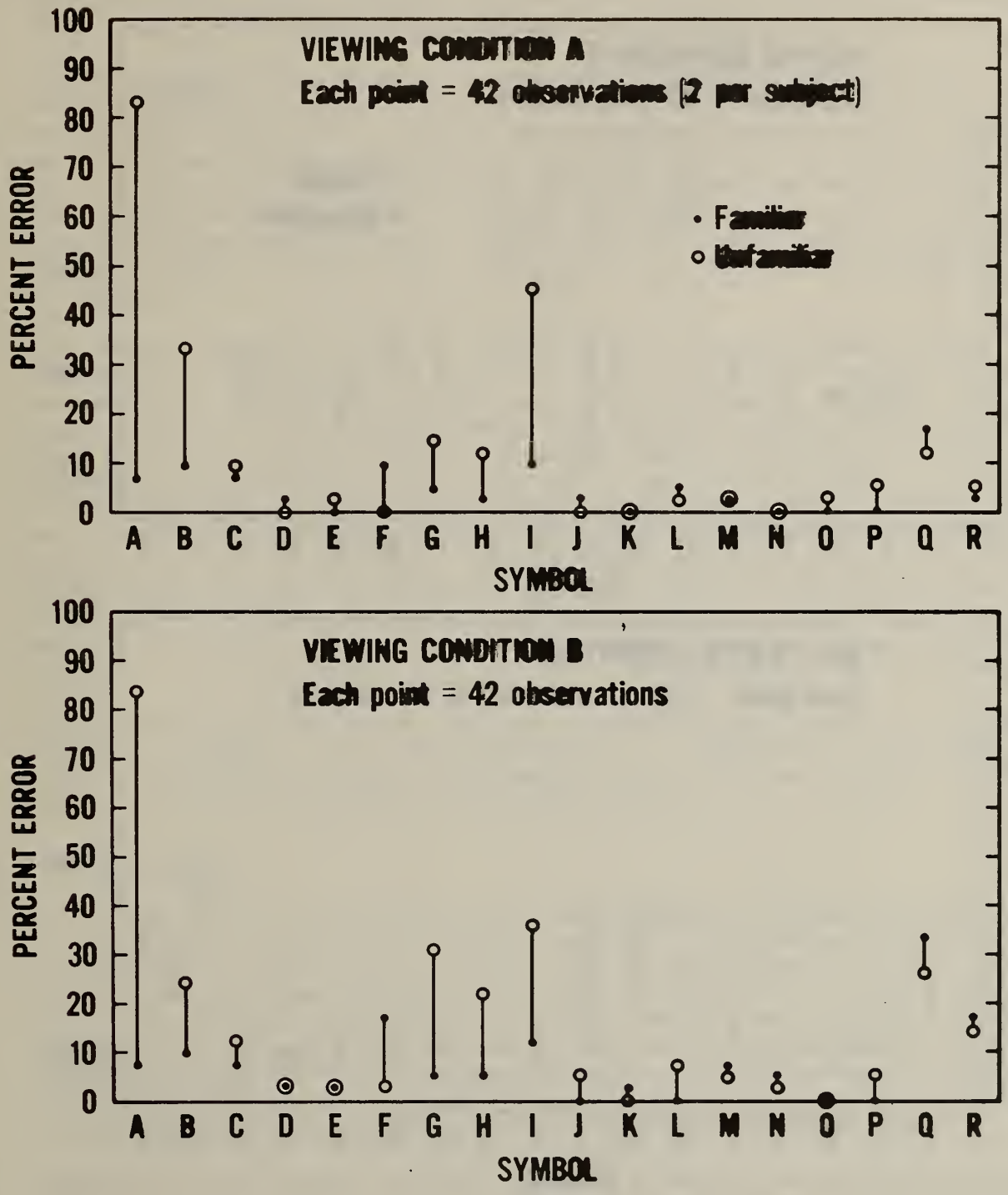

Figure 3. Percentage of errors as a function of viewing condition

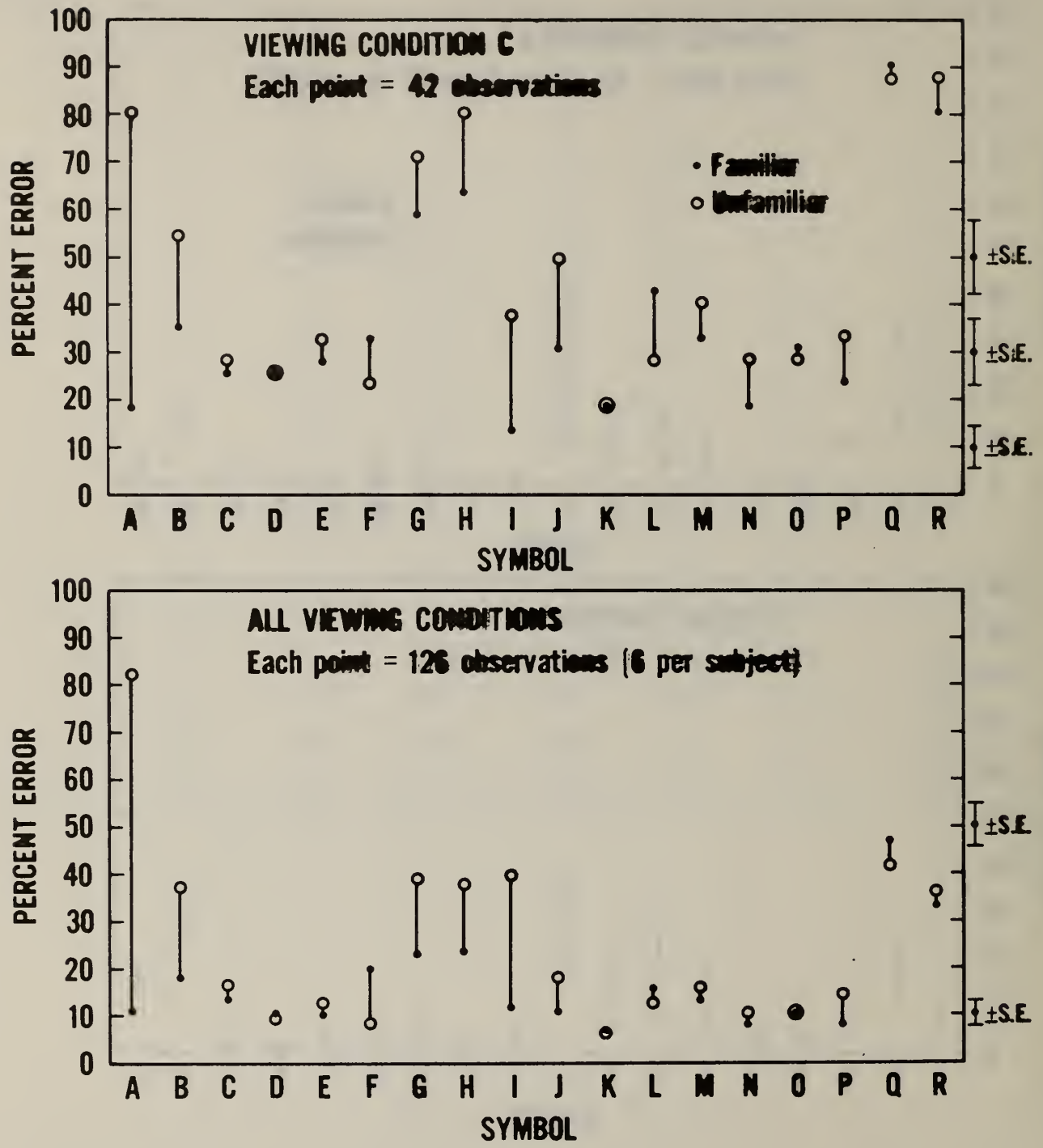

Figure 3. Percentage of errors as a function of viewing condition (continued)

correct responses, under the easiest viewing condition indicates that, when familiar, the symbols were well comprehended. Thus, poor performance under more difficult viewing conditions may be attributable to visibility decrements, rather than to inherently poor understanding.

Under the intermediate viewing condition, performance decrements became more pronounced. Fourteen of the 18 symbols still showed fewer than 10 percent errors when familiarized. However, the performance associated with symbols Q and R (outline figures) deteriorated. Symbols G and H, (a person, fire and a door or an arrow) showed poorer performance for unfamiliarized, though not for familiarized subjects. Symbol F (person and flames) was unusual in that the familiar subjects made 14 percent more errors than unfamiliarized subjects. A similar reversal, though smaller, also occurs for the other viewing conditions for symbol F.

When viewing was most difficult, symbols Q and R (outline figures) were identified as "exit" at a very low rate, similar to that of the foil stimuli (see table 3). These symbols thus, were the least visible. Symbols G and H also resulted in poor performance with even familiarized subjects showing about 60 percent errors. Symbol I showed the lowest error rate (14 percent) for familiarized subjects, with symbols A, K, and N at 19 percent. Error rates for the others were roughly in the 25-35 percent range (symbol L showed a higher rate for familiarized subjects, but a lower rate for unfamiliarized subjects suggests this may be spurious). Examination of the data in table 2 for familiar subjects only reveals that degrading viewing conditions clearly increases the percentage of errors. Of interest, though, is the fact that some symbols, such as B, G, H, L, Q, and R, are affected to a greater extent by the degradation in viewing. For other symbols, A, I, K, and N, the degradation is much less marked.

Across all viewing conditions, the data indicate symbol Q to be least visible, followed by symbol R, and then symbols G and H. Performance is generally better for the other symbols, with symbol K one of the most generally visible symbols for all three viewing conditions studied.

4.3 FAMILIARITY

The overall effect of familiarity with the symbols was to decrease the number of errors made under the best viewing condition. Nevertheless, for the majority of exit symbols, error rates were quite similar regardless of whether or not subjects had been familiarized with the specific symbol. Of course, since there were similarities between many of the symbols, even subjects nominally unfamiliar with a symbol may have benefitted from viewing related symbols. A clear improvement in performance due to familiarization was observed for six symbols: A, B, G, H, I, J. Before discussing these, some points regarding the symbols not showing an effect of familiarization should be noted.

Symbols C, D, and E might have been expected to benefit from familiarization, since previous research (Lerner and Collins, 1979; Collins, Lerner, and Pierman, 1982) had shown these symbols to have ambiguous meaning. Since symbols D and E were conceptually very similar, familiarization for one symbol could generalize to increase familiarity with the related symbol. To assess this hypothesis,

data only from subjects unfamiliarized with both symbols D and E were examined. The error rates (over all three viewing conditions) were slightly higher, 13.9 percent (10 of 72) for D and 16.7 percent (12 of 72) for E. However since these data were obtained with only 12 subjects, interpretation is difficult, and in any case, any effect of familiarization for D and E is small, and limited to the most difficult viewing condition. Similarly, the absence of an effect of familiarization for the arrow (symbol C) should not be attributed to familiarization with the other symbols (D and E) having an arrow as a central feature. Only five subjects were unfamiliarized with C, D, and E; but of 30 observations of symbol C by these subjects, only two were in error. Thus, this finer analysis does not contradict the conclusion that no substantial effect of familiarization exists for symbols C, D, and E.

The largest effect of familiarization was for symbol A, proposed by the Department of Transportation (AIGA, 1979). Without the benefit of familiarization, the symbol simply was not recognized (over 80 percent errors regardless of viewing condition). Another abstract symbol, B, once proposed by ISO, also was poorly recognized when familiarization did not occur (37 percent errors). While more representational, symbol I was frequently misinterpreted by unfamiliarized subjects (40 percent errors). Symbols A, B, and I not only showed the largest overall effects of familiarization--they also were the only symbols to show substantial familiarization effects even under the most favorable viewing condition.

For other symbols, familiarization improved performance only under degraded viewing conditions. Symbols G, H, and J showed pronounced effects of familiarization when viewing became more difficult, but were generally correctly identified under the most favorable viewing conditions. Symbols G and H were the only exit symbols appearing in a circular, rather than square or rectangular, surround. The circular surround may have contributed to confusion, especially where viewing conditions made image details difficult to discriminate. For example, those subjects who saw neither of the circular symbols during familiarization showed especially high error rates: for six subjects, 36 percent of all observations were in error for both G and H; 75-83 percent of the most difficult observations were in error. The red color in these symbols may also have contributed to problems, since the inherent brightness contrast was lower than with the black-and-white symbols. The effects of color contrast are discussed further in section 4.4.3.

Although symbols J and K resemble one another, their response to familiarization is different for degraded viewing conditions. Despite the conceptual similarities between symbols J and K, the figure-ground relationship is more complex in J. Symbol J shows not only a doorway, but a door, detached from the doorframe and foreshortened to indicate depth. The running figure is superimposed on this background. Familiarization with this symbol has a substantial effect only when viewing condition is poorest. It appears likely that familiarization does not so much clarify the meaning of this symbol, which is well-understood under better viewing conditions, as it helps the subject to analyze the symbol features under difficult viewing conditions. Further discussion of the understandability of these symbols will be found in section 4.7.

The large effects of familiarization for some exit symbols must be taken into account when the visibility of the various symbols is compared. Nevertheless at least several symbols, including K, N, and P, performed reasonably well whether familiarized or not, under all three viewing conditions. These data thus suggest that the graphic features of these particular symbols contribute to good visibility as well as good "understandability". In the following sections the graphic features of both the exit and foil symbols will be discussed in detail.

4.4 FEATURES OF EXIT SYMBOLS RELATED TO PERFORMANCE

A comparison of subjects' performance for the various exit symbols permits a number of generalizations regarding specific graphic features. Since in most cases these features were not explicitly varied in a controlled manner, a number of variables may be confounded; therefore these inferences must be regarded as tentative.

4.4.1 Filled Versus Outline Figures

Symbols Q and R were identical to symbols O and P except that they were drawn as outline, rather than solid figures. The outline figures were not only less visible (or correctly identified less frequently under degraded viewing conditions) than their filled counterparts, they were the least visible of all exit symbols tested. The use of solid figures has been recommended by researchers (Easterby, 1970) and is in fact typically used. However, the ISO standard that provides general principles for graphic symbol design (ISO, 1976) recommends avoiding filled areas. A proposed revision (ISO, 1980) reverses this position for public information symbols. The magnitude of the decrement in visibility observed in the present experiment strongly suggests the use of filled rather than outline figures.

4.4.2 Direction of Figure-Ground Contrast

Symbols O and Q were identical to symbols P and R except that the former portrayed black figures on a white background, and the latter white figures on a black background. Both directions of figure-ground contrast are commonly used. While some guides have recommended one version as being more easily perceived (DoT, 1974), experimental evaluations have shown small and variable effects (Konz and Mohan, 1972; Lerner, 1981). In this experiment, there was no observed difference between the performance for symbols O and P, while the performance for symbol Q (black on white outline figure) was somewhat poorer than that for symbol R. Across the entire set of symbols, A, B, C, H, J, L, and M also portrayed white figures on darker backgrounds. Subjects' performance for these symbols as a group was not noticeably different from that for the remaining symbols, with a range of results for both types of symbols. In all, the data do not reveal any substantial difference in performance with either direction of figure-ground contrast.

4.4.3 Color

Under the viewing conditions of the experiment, chromatic information was limited and there was little subjective sense of color. The overall luminance of about 1 cd/m^2 probably resulted in mesopic rather than true scotopic vision, however. The major effect of the various color combinations studied was presumably through differences in brightness contrast, with some combinations producing greater contrast than others. The physical contrast measurements reported in the Method section suggest that black and white should be superior to green and white or red and white. The differences in physical contrast may not have been great enough to result in larger perceptual differences, however. Although symbols H and G which contained red elements were among the least visible symbols, color was confounded with shape and other features, making interpretation difficult. There was no overall indication that the black and white symbols were superior to the green and white symbols, however.

4.4.4 Surround Shape

Twelve of the eighteen exit symbols included a square symbol surround, three a rectangular surround, and two a circular surround. A final symbol (A), while circular in shape, had no actual surround. Symbols with a rectangular surround did not show any substantial effect of familiarization and were not distinguishable from the square-surround symbols. In contrast, the symbols with circular surrounds showed substantial effects of familiarization, and poor visibility even for familiarized subjects. The confounding of surround shape with color makes interpretation difficult, but the case for an effect of surround shape will be discussed in section 4.5.2. It seems likely that subjects have certain expectancies regarding the surround shape of exit symbols, although it is also possible that the familiarization portion of the experiment may have contributed to such stereotypes, since the majority of exit symbols presented were in square or rectangular surrounds.

4.4.5 Relationship of Graphic Elements and Figure-Ground Contrast

Eleven of the exit symbols employ the concept of a human figure exiting through a doorway. Literally, this concept implies an interaction, in three dimensions, between a human figure and a doorway, which can be graphically complex. This problem has been approached in different graphic ways among the symbols. For purposes of this discussion, symbols L, P, Q and R are not explicitly discussed, since they are conceptually identical to symbols M or O.

Three symbols (H, J, K) attempt to portray three-dimensionality; three (I, M, O) are two-dimensional portrayals, with the figure displaced from the doorway; and one (N) shows the interaction of figure and door in a more symbolic fashion, by altering the figure color, for contrast, as it enters the doorway. Since symbols K, N, and O are among the most visible symbols, and did not show familiarization effects, all three approaches appear viable, and none is clearly favored by these data. However, within a graphic approach, the individual symbols vary considerably. Comparing symbol K with J and H suggests the advantage of simplifying the interacting elements and providing a simple background against which the figure may be viewed. The poor performance of unfamiliarized subjects for

symbol I indicates further that the door, too, must be readily recognizable. While the data do not favor one particular approach, these limited comparisons do suggest simplifying both elements and minimizing the overlap of the graphic details of the figures and doors.

The more complex the graphic image was, as indicated by a greater number of features, the greater the number of errors occurring for the poorest viewing condition. For example, symbols G, H, L, and M all contain three major features, consisting of a human figure, an arrow, a door, or flames. These symbols have error rates among the highest, from 33 percent to 64 percent, except for the outline symbols Q and R (discussed in 4.4.1). Symbols with several major graphic elements may suffer from complexity itself or from the reduced size of each element when several are combined.

4.4.6 Specific Pictorial Elements

Certain pictorial elements commonly occur in symbols for exits and emergency exits (Lerner and Collins, 1980). These elements include human figures, flames, arrows, and doorways. When Lerner and Collins had experimental subjects in a study on fire-safety symbols sketch a pictogram for "exit" or "fire exit," no consensus stereotype image occured, but these common pictorial elements often emerged. None of these elements is in itself adequate to portray the exit message unambiguously, but each may contribute importantly to the successful graphic portrayal of the exit message. The data from the present experiment were examined to see if any of these elements were consistently associated with good performance for both familiarized and unfamiliarized subjects.

For the limited sample of symbols, no striking effect of figures, flame, or doors was observed: each of these elements occurred among all symbols, regardless of percentage of correct identification. Further indications of the role of some of these factors are discussed below regarding foil stimuli. The most interesting observation among the exit symbols was in how readily the arrow (C), and the diagrammatic symbols incorporating the arrow (D and E), were interpreted as "exit." Even unfamiliarized subjects had more than 90 percent correct response under the most favorable viewing conditions. This finding differs from other experiments (Lerner and Collins, 1979; Collins, 1982; Collins et al., 1982) in which such symbols were less frequently interpreted as exit indicators, even though the viewing condition was not degraded. Three other symbols (G, L, M) incorporated smaller arrows into the pictogram. Of these, symbol G had a somewhat higher error rate for unfamiliarized subjects, even under the easiest viewing condition. The arrow is discussed further when errors for foil stimuli are presented (section 4.5).

The specific factors which appear to decrease the visibility (increase errors in accurate identification under poor viewing conditions) of exit symbols include the use of outline figures, larger number of graphic features, and use of circular surround shapes. Factors which do not appear to degrade visibility substantially are the direction of figure-ground contrast and differences in color contrast between black and white and green and white.

4.5 FOIL SYMBOLS

Features which appear to influence the interpretation of a symbol as an "exit" symbol can be inferred from an analysis of those foil symbols falsely identified as "exit". Table 3 presents the percentage of times each foil symbol was incorrectly identified as "exit" under each of the three viewing conditions, (2.7, 3.0, 3.3) as well as the average error rate (incorrect identifications) across all conditions. (Note that table 3 presents data for 108 different symbols, so that 34X is not the same symbol as 34Y or 34Z.) Error rates ranged from zero to over 80 percent. Some foil symbols showed the highest error rates under the easiest viewing condition, indicating the message as portrayed was confusable with "exit". Errors occurred more frequently for most foil symbols, however, as the viewing condition was made more difficult. (Foil symbols are depicted in appendix A.)

Table 4 lists those symbols for which the highest overall error rates occurred (greater than 10 percent), in the order of error rate. This include approximately one-third of the foil symbols. The table also lists certain graphic features that frequently occurred in these symbols.

Two aspects of the data obtained for the foil symbols will be discussed. First, the intended messages represented among the high-error symbols will be reviewed. Secondly, generalizations regarding those symbol features that contribute to confusion will be considered. In comparing symbols, two factors should be kept in mind. First, since many features covary between symbols, interpretation of differences between symbols is necessarily speculative. Secondly, the error variance of the proportion of errors for each symbol should be kept in mind. The estimated standard error is about 4 percent when the error rate is 5 percent, and ranges up to a maximum of about 9 percent for 50 percent errors.

4.5.1 Intended Messages

The symbol most frequently confused with exit was the directional arrow (Z28). This arrow was intended by ISO TC 21 (1978) to indicate direction as a supplement to a particular sign. Of course, half of the subjects had seen another arrow (symbol C) familiarized as meaning "exit"; still, those not shown symbol C still identified the directional arrow as "exit" at about the same rate (76 percent overall). The problems arising from the confusion of exit symbols with directional indicators are detailed in Lerner (1981), along with suggestions for reducing such problems.

Two versions of the message "use stairs not elevator, in case of fire" were included as foil stimuli. One, which did not show an elevator (X34), had substantial (60-77 percent) confusions at all viewing conditions. The other (X8), showed a much lower overall rate (9.5 percent). However, since errors for this latter symbol were greater (17.9 percent) under the most favorable viewing condition, the low overall rate may simply indicate that this symbol can not be discriminated well enough to be confused with exit under poor viewing conditions. When it is seen well, the message is apparently confusable. Both of these symbols are intended to be used on or near elevators. This context may improve meaningfulness in actual use - however, the danger that the elevator

Table 3. Percentage of Times Each Foil Symbol is Incorrectly Identified as Exit (Percent Errors for Foil Stimuli Under Each Viewing Condition)

	List X				List Y				List Z			
	2.7	3.0	3.3	Overall	2.7	3.0	3.3	Overall	2.7	3.0	3.3	Overall
1	0.0	7.1	14.3	7.1	7.1	3.6	3.6	4.8	3.6	7.1	14.3	8.3
2	3.6	10.7	14.3	9.5	0.0	0.0	3.6	1.2	3.6	3.6	7.1	4.8
3	7.1	17.9	10.7	11.9	0.0	7.1	10.7	6.0	0.0	3.6	10.7	4.8
4	14.3	14.3	10.7	13.1	3.6	3.6	3.6	3.6	3.6	7.1	10.7	7.1
5	0.0	7.1	14.3	7.1	0.0	0.0	7.1	2.4	3.6	0.0	0.0	1.2
6	0.0	3.6	10.7	4.8	3.6	0.0	0.0	1.2	3.6	7.1	14.3	8.3
7	60.7	78.6	60.7	66.7	21.4	28.6	21.4	23.8	0.0	0.0	10.7	3.6
8	17.9	7.1	3.6	9.5	10.7	7.1	17.9	11.9	3.6	17.9	21.4	14.3
9	0.0	0.0	7.1	3.6	9.5	10.7	7.1	4.8	3.6	0.0	10.7	4.8
10	0.0	0.0	14.3	4.8	0.0	7.1	10.7	6.0	0.0	0.0	3.6	1.2
11	0.0	0.0	7.1	2.4	0.0	3.6	10.7	4.8	0.0	7.1	7.1	4.8
12	3.6	0.0	17.9	7.1	7.1	7.1	7.1	7.1	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	14.3	6.0
14	0.0	0.0	7.1	2.4	0.0	0.0	10.7	3.6	0.0	0.0	3.6	1.2
15	0.0	0.0	10.7	3.6	0.0	0.0	7.1	2.4	0.0	0.0	3.6	1.2
16	14.3	10.7	0.0	8.3	17.9	21.4	14.3	17.9	7.1	14.3	25.0	15.5
17	3.6	3.6	21.4	9.5	10.7	28.6	14.3	17.9	7.1	0.0	14.3	7.1
18	3.6	14.3	35.7	17.9	21.4	42.9	17.9	27.4	0.0	10.7	21.4	10.7
19	3.6	7.1	28.6	13.1	7.1	17.9	14.3	13.1	10.7	21.4	10.7	14.3
20	0.0	3.6	14.3	6.0	0.0	0.0	7.1	2.4	7.1	7.1	17.9	10.7
21	3.6	0.0	14.3	6.0	10.7	39.3	25.0	10.7	10.7	10.7	10.7	10.7
22	0.0	0.0	10.7	3.6	3.6	3.6	3.6	3.6	7.1	3.6	7.1	7.1
23	0.0	7.1	25.0	10.7	7.1	3.6	10.7	7.1	7.1	3.6	21.4	10.7
24	0.0	3.6	7.1	3.6	3.6	10.7	0.0	4.8	7.1	32.1	17.9	17.9
25	10.7	17.0	7.1	11.9	0.0	0.0	7.1	2.4	0.0	3.6	10.7	4.8
26	0.0	3.6	0.0	1.2	0.0	3.6	10.7	4.8	32.1	35.7	35.7	34.5
27	14.3	14.3	25.0	17.9	3.6	3.6	3.6	3.6	3.6	7.1	17.9	9.5
28	0.0	3.6	14.3	6.0	0.0	0.0	3.6	1.2	85.7	85.7	39.3	70.2
29	10.7	7.1	10.7	9.5	7.1	17.9	10.7	11.9	14.3	39.3	46.4	33.3
30	3.6	17.9	7.1	9.5	3.6	14.3	10.7	9.5	25.0	14.3	10.7	16.7
31	3.6	3.6	14.3	7.1	3.6	7.1	14.3	8.3	3.6	7.1	10.7	7.1
32	3.6	7.1	7.1	6.0	0.0	10.7	0.0	3.6	0.0	3.6	3.6	2.4
33	3.6	21.4	7.1	10.7	14.3	3.6	3.6	7.1	0.0	3.6	7.1	14.3
34	82.1	60.7	21.4	54.8	39.3	14.3	14.3	22.6	3.6	14.3	25.0	14.3
35	0.0	3.6	7.1	3.6	0.0	0.0	10.7	3.6	0.0	7.1	3.6	3.6
36	0.0	0.0	17.9	6.0	21.4	17.9	14.3	17.9	7.1	7.1	17.9	10.7

Table 4. Foil Symbols with More Than 10 Percent Errors (34 of 108)

	Symbol	Overall %	Fig.	Arrow	Flame	Door	Door Propor.	Stair	Feet	Surround		
1	Z 28	70.2		✓						Rect	R	ISO Arrow
2	X 7	66.7	✓			✓				Square	R	No exit
3	X 34	54.8	✓		✓			✓		Square	B&W (R)	Use stair in fire
4	Z 26	34.5								Square	R	Ladder
5	Z 29	33.3					✓			Square	R	Standpipe
6	Y 18	27.4		✓		✓				Circle	Blu	Close fire door
7	Y 21	25.0	✓	✓						Square	G	Shower
8	Y 7	23.8								Circle	R	DOT No entry
9	Y 34	22.6		✓						Triangle	Y	Old ISO No exit
10	X 18	17.9								Circle	B	Mandatory Action
11	X 27	17.9								Square	R	FF equip.
12	Y 16	17.9							✓	Circle	Blu	ISO Boots
13	Y 17	17.9								Circle	Blu	Glove
14	Y 36	17.9							✓	Square	B&W	Slip
15	Z 24	17.9	✓							Circle	R	Forklift
16	Z 30	16.7		✓						Square	R	Wall w/arrow
17	Z 16	15.5							✓	Circle	Blu	Boot
18	Z 8	14.3	✓			✓				Square	B,W,R	No exit ISO
19	Z 19	14.3					✓			Square	Blu	Elec. shutoff
20	Z 34	14.3	✓							Square	B&W	Fall from ledge
21	X 4	13.1	✓							Triangle	Y	Slip
22	X 19	13.1					✓			Square	Blu	Elec. shutoff
23	Y 19	13.1			✓		✓			Square	Blu	Gas shutoff
24	X 3	11.9								Triangle	Y	Forklift (with driver)
25	X 25	11.9			✓					Circle	R	Flammable
26	Y 8	11.9	✓			✓				Circle	R	No exit
27	Y 29	11.9								Square	R	Standpipe
28	X 23	10.7								Square	R	Emerg. Phone
29	X 33	10.7						✓	✓	Circle	Y	Trip
30	Z 18	10.7					(archway)			Circle	Blu	Ear muff
31	Z 20	10.7					✓			Square	G	Eyewash w. head
32	Z 21	10.7								Square	G	Shower drops
33	Z 23	10.7								Circle	R	Explosion AF
34	Z 36	10.7		✓						Square	B&W	Falling objects

could be construed as an emergency exit facility during a fire raises concern about the use of these symbols.

Symbols intended to warn explicitly that a route does not lead to safe egress - "no exit" - were interpreted as "exit" with alarming frequency. The majority of subjects interpreted symbol X7 as exit under all conditions. While Y8 and Z8 were confused much less often, both showed about 20 percent confusions when viewing was most difficult. The elements of these symbols (moving figure, door) are common to many exit pictograms, and apparently the indication of prohibition (slash, X, lock) is less effective when visibility is poor. Symbol Y34 is based on a diagram, showing an arrow entering a closed rectangle. Previous experiments on symbol understandability (Collins and Pierman, 1979; Lerner and Collins, 1980) under good viewing showed this to be a poorly understood image, with frequent egress-related misinterpretations. The present results confirm this finding, with this image being confused with exit especially under the most favorable viewing condition (39.3 percent). The high rate of confusions may partly reflect the intentional use of a procedure that predisposed subjects to look for exit messages. Nevertheless, the data obtained in the present experiment further support the inadequacy of symbols and messages for "no exit." The inadequacy of the entire set of "not an exit" symbols appears to be a critical problem in the design of symbols for life safety. This message appears to be very difficult to symbolize effectively and may be better conveyed by words (to those who are literate).

Five "No Entry" symbols were evaluated. Three (X9, Y9, Z9) were similar in graphic concept, showing a human figure, overlaid with prohibitory circle and slash. Error rates were low for these symbols, in contrast to the "no exit" symbols. Similarly, symbol Z7 was infrequently interpreted as exit. In contrast, the abstract DoT "No Entry Symbol" (Y7) was misinterpreted as "exit" over 20 percent of the time under all viewing conditions. This poor performance occurs despite the wide use of this symbol for highway signage, for transportation facilities, and for other public settings. In addition, understandability data obtained by Collins et al., (1982) indicate that only 30-50 percent of those tested identified this symbol correctly, further evidence of its ineffectiveness. Under building emergency conditions, this common symbol could send people searching for a way out in an inappropriate direction.

The set of fire safety symbols proposed by ISO (1978) includes several to indicate the location of firefighting equipment. Of these, "Ladder" (Z26) and "Location of Equipment" (X27) showed confusions with "exit", confirming the earlier findings by Lerner and Collins (1980). The fire hose and reel (Standpipe) symbol (Z29) was also frequently interpreted as exit in the present experiment unlike previous experiments using good viewing conditions. This probably occurred because the fine separation in the folds of the hose cause the degraded image to appear as a rough rectangle with the proportions of a doorway. In contrast, two symbols (X29, Y29), which incorporate a modified version of the standpipe resulted in much lower error rates (about 10 percent overall); however, the modification is confounded with other graphic differences, so that straightforward interpretation is not possible.

One version (Y21) of the safety shower message was interpreted as "exit" one-fourth of the time. Although Collins et al., (1982) found this symbol to be interpreted correctly under good viewing conditions, certain of its details apparently contribute to confusion when viewing is degraded. In this symbol, a human figure is shown standing under a shower pipe which is shaped and sized as an archway. An arrow, though small, is also present. The other versions of the safety shower message (X21, Z21) result in much lower error rates.

Four of the six symbols in the category of slip, trip, and fall resulted in moderately high error rates (11-18 percent, overall) while two resulted in low rates (4-7 percent). Interestingly, two symbols showing a falling figure (X4, Z34) produced more confusions than a third image of a falling figure (Z4); and two symbols (X33, Y36) showing a foot (or feet) produced more confusions than a third showing the image of a foot (Y4). It is not apparent what factors distinguish the more confusing images from the less confusing images.

The three symbols indicating the need for safety footwear are similar to some of the slip/fall symbols in showing a boot as the primary image. Two (Y16, Z16) of these symbols showed a substantial number of confusions with "exit" (17.8 and 15.5 percent overall). The third symbol (X16) was unusual in that numerous errors occurred for the easiest viewing condition (14.3 percent), fewer in the intermediate condition (10.7 percent), and none in the most difficult condition. This symbol was the most complex one, showing a hand pulling on a boot, and portrayed the boot from an unusual angle. The lower error rate obtained under the most difficult viewing conditions may reflect a message that appears more distinguishable from "exit" or an image that loses meaning altogether.

Symbols X19 and Z19 are intended to identify the location of electric shutoff panels; Y19 is a similar symbol for gas shutoff valves. These three symbols are graphically similar and produced similar error rates of 13-14 percent, overall. Conceptually there seems little reason to expect confusions with the "exit" message. The errors may again be attributable to the basic rectangular shape suggesting a door; the throw switch on the electrical shutoff symbols might also be viewed as some form of door handle. Whatever the source of confusion, these symbols could be dangerous in emergencies if they lead viewers into utility areas rather than toward exits.

Symbols X30 and Z30 are intended to convey the location of fire department hook-ups to charged water sources. To distinguish these water supplies from hook-ups into which water is pumped, the symbol indicates a water flow from the connector. Symbol X30 does this by showing water drops; Z30 shows arrows. The comparison of the error rates indicates that the arrow contributes to confusion with "exit". Symbol Z30 has a much higher error rate (25 vs 3.6 percent) under the best viewing condition, when the small arrows are most visible.

Three similar symbols depict a flame to communicate the danger of combustion. Unlike Y25 and Z25, more errors occurred for symbol X25 (17.9 percent) under the intermediate viewing condition. The three symbols differed not only in the form of the flame, but also in flame size, surround shape, and color, all of which may have contributed to the findings. Overall, however, the low error

rate for these symbols (12 percent, 2 percent and 5 percent) does not suggest that a flame by itself is frequently interpreted as indicating a fire exit.

4.5.2 Features of Foil Symbols Related to Exit Message Confusions

The review of those messages and symbols most frequently misinterpreted as exit symbols suggests a number of graphic features that may contribute to confusion. These include surround shape, human figure, feet, arrow, and door-shape. Since these features were not systematically varied, many graphic and conceptual features may be confounded, and the effect of a given feature may be only inferred. Although any conclusions are necessarily tentative, the evidence suggesting the role of each of these features is discussed below.

Surround shape appears to be a significant factor in confusions for exit messages. It is difficult, however, to assess the effect of the symbol surround shape alone since it is confounded with message type, color, size of the enclosed image, and the pictogram image itself. Nonetheless, across the variety of symbols investigated, there is the definite indication that surround shape is a significant factor in producing exit symbol confusions. This appears to be especially true under the most difficult viewing condition, where the pictogram image is least visible. Four basic surround shapes -- square, circle, circle with diagonal slash, and triangle (apex up) -- were used for all but two of the 108 foil stimuli. In the most difficult viewing condition, fewer than one-fourth of the symbols produced error rates in excess of 15 percent; yet these were distributed very differently across the four shapes. Fourteen of 43 (33 percent) symbols with square surrounds resulted in high error rates; 9 of 31 (29 percent) symbols with circular surrounds; 1 of 12 (8 percent) with circle-and-slash surrounds; and none of 20 symbols with triangular surrounds.

Thus, across all messages, variation in surround shape for the foil symbols appears to increase the likelihood of confusions with the exit message. Where symbols for the same message are paired with more than one surround shape, further comparison is possible. For nine messages, two or more different surround shapes were used. Table 5 lists the symbols and their surround shapes in ascending order of errors during difficult viewing conditions, for each of these messages. With some exceptions, the table indicates an ordering of fewest errors for triangular surrounds, more errors for circular surrounds, and most errors for square surrounds. In summary, surround shape is an informative dimension, both on the grounds of common sign coding conventions and on the basis of the exit symbols included for this study. Yet the extent to which sign users rely on surround shape, especially as a function of symbol visibility, remains an interesting issue. Shape stereotypes for some messages may exist (Easterby and Hakiel, 1977), and experimental subjects may detect shape changes in signs (Adams and Hsu, 1981), but there is little research on the functional importance of symbol surround shape to sign users.

The presence of a full human figure in a pictogram also appears to be related to misinterpretations as "exit". While only 13 of the 108 foil symbols contained a human figure, eight of the 34 symbols with overall error rates exceeding 10 percent contained such a figure. Thus, such symbols occurred among the problem stimuli at twice the expected rate. Further, of the five symbols

Table 5. Percent Errors (Difficult Viewing Condition) for Symbols with Different Surround Shapes

Message	Symbol	Surround	% Errors
Explosion Hazard	X1	triangle	14.3
	Z23	circle	21.4
	X23	square	25.0
Entanglement Hazard	Y6	triangle	0.0
	X24	circle	7.1
	X36	square	17.9
Fork Lift Traffic	Y3	triangle	10.7
	X3	triangle	10.7
	Z24	circle	17.9
General Hazard	X6	triangle	10.7
	Z6	triangle	14.3
	X18	circle	35.0
Corrosion Hazard	Y24	circle	0.0
	Y2	triangle	3.6
	X32	triangle	7.1
Electrical Hazard	Z33	circle	7.1
	X35	square	7.1
	X2	triangle	14.3
Flammable	Y1	triangle	3.6
	X25	circle	7.1
Slip, Trip, Fall	Y4	triangle	3.6
	X33	circle	7.1
	Z4	triangle	10.7
	X4	triangle	10.7
	Y36	square	14.3
	Z34	square	25.0
Not an Exit	Y34	triangle	14.3
	Y8	circle	17.9
	Z8	circle, slash	21.4
	X7	square	60.7

containing a figure but having error rates less than 10 percent, three of these were "no entry" symbols which incorporated the prohibitory circle and slash. As discussed above, use of the circle and slash as a surround shape appears to result in low probabilities of "exit" interpretations.

In contrast to the full human figure, depictions which show only the head or torso seldom produce high rates of confusion (only two cases occur where the error rate exceeds 10 percent). While this may relate in part to the different referent messages symbolized, the data suggest that, where a head or torso can be substituted for the full figure in a non-exit message, confusions under poor visibility may be reduced.

Although only six symbols contained the image of feet or boots, four of these were among the symbols with relatively high rates of confusion. Interestingly, none of the actual exit symbols included in the experiment used such an image, yet "exit" interpretations for feet or boots still occurred. These confusions suggest that the "foot" portion of the body appears more related to "exit" than does the head or torso.

All five symbols that contained an arrow produced error rates exceeding 10 percent. Furthermore, an electrical hazard symbol (X2) with an arrowhead at the end of an electrical bolt produced a higher error rate (9.5 percent) than a similar bolt without the arrowhead (Z33; error rate of 3.6 percent). This occurred even though symbol X2 was enclosed in a triangle surround and Z33 in a circular surround. The contribution of the arrow to the "exit" connotation of a symbol has been discussed by Lerner (1981). The present findings reinforce his contention. Any use of an arrow in a non-exit message must be done with extreme caution.

All four foil symbols (X7, Y8, Y18, Z8) that included images of doors resulted in error rates exceeding 10 percent. Five other symbols (X19, Y19, Z19, Z20, Z29) had large vertical rectangular areas that were proportioned similarly to a doorway; all of these also produced error rates exceeding 10 percent. These findings suggest that it may be advisable to avoid door-shaped images or background shapes in non-exit symbols.

Representations of various types of flames and smoke appear in some of the symbols, but some of these do not depict "fire hazard". Two (X10, Z25) show a flame on a match; two (Y10, Z10) show a smoldering cigarette; and one (Y19) has a flame symbol indicating natural gas. Of the eight symbols actually containing representation of a fire, only two produced more than a 10 percent error rate; for all thirteen symbols with any sort of flame or smoke, only three produced more than 10 percent errors. Since about one-third of all symbols resulted in error rates above 10 percent, the frequency of images with flame or smoke in the exit confusion category is even less than might be expected. Thus, there is no evidence that images of fire tend to increase confusions with "exit." This occurs even though three of the exit symbols included in the experiment contained flames along with their other graphic elements.

4.6 SUMMARY - SYMBOL FEATURES RELATED TO THE SUCCESSFUL EXIT MESSAGE

Based on the detailed consideration of the exit and foil symbols, some generalizations for exit symbology may be summarized. These generalizations are all tentative, subject to the limitations discussed previously.

For exit symbols, a square surround appears preferrable to a circular surround, and white with green or black may be preferable colors to white and red. Triangular surrounds are clearly not associated with the message of exit. Filled figures are more visible than outline figures. No common pictogram element was clearly more critical than others; however, the combination of a human figure with a doorway or arrow appears to be effective in conveying the exit message under most viewing conditions. The arrow also appears effective. The interactions of the graphic elements (human figures and doorways) should be simplified; however, with figures presented against an uncomplicated background. In contrast, the highly abstract symbols did not evidence any advantage in visibility that would offset their poor understandability to subjects not familiarized with them.

For the non-exit symbols, confusions with exit can be reduced by use of a triangular surround, but increased by using rectangular surrounds. If a person is shown, portraying just the head or torso, leads to fewer such confusions than showing the entire human figure. On the other hand, feet tend to encourage "exit" interpretations. Doorways, or rectangular shapes proportioned as doorways, should be avoided in non-exit symbols. Arrows also tend to lead to confusions with "exit", and should be used cautiously in non-exit symbols.

4.7 COMPARISON WITH OTHER EXIT SYMBOL EVALUATIONS

The subject's task in the present experiment was an attempt to simulate the task confronting a person in an emergency situation. The subject looked for an exit message under viewing conditions degraded to make that decision more realistic and difficult. A number of other evaluations of safety and informational symbols have assessed the meaningfulness of symbols for the exit message, without introducing any degradation in viewing. Results from these other experiments can be examined to provide further insight about the meaningfulness of the specific exit symbols studied in the present experiment.

Of the 18 exit symbols studied in the present experiment, all but 5 have been assessed elsewhere for meaningfulness. Table 6 summarizes the data from these assessments for each symbol, in terms of percentage of correct identification, scoring criterion (strict or lenient), number of subjects, method, and authors of the reported research. The percentages of correct identifications in the various experiments should not be taken too literally or treated as directly comparable due to many methodological differences. They are presented here to give some idea of the overall "meaningfulness" of each exit symbol, as indicated by the percentage of times that people can correctly indicate that a symbol means "exit". These findings may be compared with the results of the present experiment given in table 2. (Note, however, that table 2 presents error rates, while table 6 presents percentage correct data).

Table 6. Supplementary Data on the Understandability of Selected Exit Symbols

Symbol	Percentage Correct: Strict Criterion	Percentage Correct: Lenient Criterion	Number of Ss	Method	Authors
A	2.3	26.7	86	Definition	Collins et al., 1982
	1.6	6.6	61	Definition	
B	2.2	62.2	45	Definition	Lerner & Collins, 1980
	57.8		46	Multiple choice	
	25.0		143	Definition	Collins & Pierman, 1979
C	2.2	6.7	45	Definition	Lerner & Collins, 1980
	22.2			Multiple choice	
	17.0		143		Collins & Pierman, 1979
D	66.0			Matching	Zwaga & Boersema
	37.6		200	Definition	Easterby & Graydon, 1981
E	39.8	59.1	88	Definition	Collins et al., 1982
	68.5	83.3	54		
	72.1		129	Multiple choice	Collins, in prep.
F	37.1		200	Definition	Variant - Easterby & Graydon, 1981
G	86.7	91.1	45	Definition	Lerner & Collins, 1980
	95.7		46	Multiple choice	
	90.7	93.0	86	Definition	Collins et al., 1982
	82.0	82.0	61	Definition	
	89.3		131	Multiple choice	Collins, in prep.
H	90.4	95.7	94	Definition	Collins et al., 1982
	83.0	88.7	53	Definition	
I	--	--	--	--	--
J	68.9	86.7	45	Definition	Lerner & Collins, 1980
	69.2			Multiple choice	
	64.8	72.7	88	Definition	Collins et al., 1982
	68.5	83.3	54	Definition	
K	91.5		130	Multiple choice	Collins, in prep.
L	82.9	90.3	94	Definition	Collins et al.
	79.2	86.7	53	Definition	
M	53.2		200	Definition	Easterby & Graydon, 1981
N	55.7		122	Multiple choice	Collins, in prep.
O	--				
P	--				
Q	--				
R	--				

Inspection of table 7 reveals that the various candidate exit symbols differed widely in terms of percentage of correct identification. Symbols, A, B, and C, for example, were generally understood by fewer than 25 percent of the participants, depending on the method and scoring criterion used. Symbols D, E, F, J, M, and N received higher percentages of correct responses, but with scores generally below 75 percent correct. ISO has previously suggested that symbols with scores below this range are not acceptable as substitutes for word messages. Only symbols G, H, K, and L received percentages of correct responses above 75 percent.

Compared with research from experiments in which subjects defined exit symbols only as a subset of safety symbols, there was a greater tendency to identify symbols as "exit" symbols in the present experiment. Agreement was very close for some symbols (A, C, G, H) and quite different for others (D, E, F, J, M, N). There was also a greater tendency to interpret other non-exit symbols as "exit" more frequently in the present experiment. It should be remembered that the subject's task here was to determine if a symbol were an exit symbol or not, and that each subject was familiarized with a subset of exit symbols. Consequently, subjects were somewhat biased toward identifying a particular symbol as an "exit". This increased tendency to identify symbols as indicating "exit" can be interpreted in a number of ways. Guessing in the absence of information might account for some of the increase, although the generally low rates of errors for foil stimuli limit the extent to which this can account for the data. More likely, since subjects were specifically told to look for "exit" symbols, the procedure may have caused a shift in a subject's criteria for decision. The poor viewing conditions may also have altered search strategies, so that symbols were evaluated more in terms of isolated features than holistically. Further, since subjects were searching for a class of symbols, performance may have been based on a comparison with some internal model, or "search image." In other research contexts, performance has been related to how "representative" an item is as an example of its class (Mervis and Rosch, 1981). Whatever the reason, the present increase in "exit" interpretations emphasizes two points. First, competing messages from other signage during an emergency can cause confusion and a significant amount of serious error. Any sign bearing resemblence to an exit symbol may be interpreted as indicating "a way out." Secondly, what may appear to be relatively minor features of a symbol, for exit or other messages, may have a significant influence on interpretation under the poor viewing conditions existing in emergency conditions.

5. CONCLUSIONS

In the preceding pages, experimental data on the visibility of exit and foil symbols were presented for a series of degraded viewing conditions. The present experiment attempted to separate the effects of familiarity and visibility by familiarizing subjects with a random half of the exit symbols. This attempt isolated a number of exit symbols which could be correctly identified as exit under poor viewing conditions, only if familiarized. It also isolated another set of exit symbols with low error rates regardless of familiarization. This latter class of symbols is important because of the authors' conviction that a good exit symbol should have good initial understandability and good visibility under all viewing conditions. Furthermore, under the stress of a building emergency, a more inherently meaningful image may retain its effectiveness to a greater extent than one which must be learned.

When combined with other research on exit symbols, data from the present experiment, including the use of foil symbols, allowed the identification of a a number of graphic features which appear to contribute to the understandability and visibility of an exit symbol. These features include: use of solid figures, use of square/rectangular surrounds, use of full human figures, and minimization of interaction among symbol elements. The data obtained for the foil symbols indicate a variety of features that are associated with the successful exit message. Analysis of those symbols frequently confused with "exit" indicates that they contain features which appear to contribute to accurate identification of exit messages. These include: presence of a full human figure, vertical rectangular elements, arrows, and human feet. Features which do not seem to lead to confusions with the exit message include: use of a triangular surround, presence of flames, and presence of a human head, hands, or torso. The data suggest that symbolic versions of the exit message which combined a human figure with a doorway or an arrow appeared to be most effective under all viewing/familiarization conditions.

Data from the present experiment, when combined with data from those experiments which determined initial understandability, strongly suggest that a symbol which contains the graphic features of symbol K (see figure 2) can effectively symbolize the message "exit", even under the poorest viewing conditions. Symbol K, showing a person and an open door, demonstrated both good initial understandability and good visibility for all viewing conditions, regardless of familiarization. Although symbol J contains many of the graphic features of symbol K, and has good initial understandability, it received a much greater number of errors than symbol K in the poorest viewing conditions of the present experiment. Although the number of errors for symbol A when familiarized is almost as low as for symbol K under poor viewing conditions, the dramatic increase in errors (from 11.1 to 82.5 percent) for symbol A when NOT familiarized suggests that this symbol may have limited effectiveness. Its very poor initial understandability (between 2 and 25 percent in Collins et al., 1982) would appear to reinforce this contention. Consequently, symbol K appears to be one of the most effective symbols studied in the present experiment. Japanese research (1980) has also indicated the effectiveness of this symbol in smoke conditions. As a result, the symbol which is in wide use in Japan (see figure 4), has been recommended by the Japanese (1980) to ISO for consideration as an Exit symbol.

Figure 4. Japanese exit symbol in use

Its apparent effectiveness in communicating the exit message to people in the U.S. and Japan, as well as its good visibility under poor viewing conditions suggest that this proposal deserves further consideration.

In conclusion, the results of the preceding experiment indicate that there are exit symbols which are both visible under degraded viewing conditions such as smoke, and understandable without prior, deliberate familiarization. Although word messages can be used to reinforce the understandability of a symbolic indicator, it is essential to select life-safety symbols which have good initial understandability and good visibility under all viewing conditions. Such symbols have been identified in the present experiment.

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APPENDIX A - FOIL SYMBOLS

FOIL SYMBOLS FROM LIST X

1. Explosion

2. Electricity

3. Forklift

4. Slip

5. Poison

6. General Warning

7. No Exit

8. Use Stairs in Fire

9. No Entrance

10. No Open Flame

11. Do Not Lock

12. Fire Extinguisher

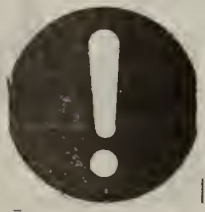
13. Wear Hard Hat

14. Wear Ear Protection

15. Wear Respirator

16. Wear Safety Shoes

17. Wear Safety Gloves



18. General Warning

19. Electricity Shut-Off

20. Eyewash

21. Safety Shower

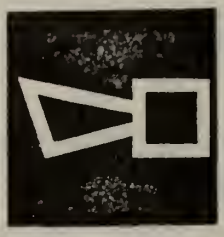
22. Break Glass

23. Explosion

24. Entanglement

25. Flammable

26. Fire Hydrant



27. Fire Alarm

28. Alarm Call Point

29. Connection

30. Connection

31. Shut-Off

32. Corrosion

33. Trip

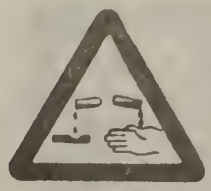
34. Use Stairs/Fire

35. Electrical

36. Entanglement

FOIL SYMBOLS FROM LIST Y

1. Flammable



2. Corrosion

3. Forklift

4. Slip

5. Radiation

6. Entanglement

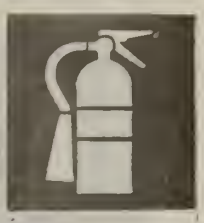
7. Do Not Enter

8. No Exit

9. Do Not Enter

10. No Smoking

11. No Water on Fire



12. Fire Extinguisher

13. Wear Hard Hat

14. Ear Protection

15. Wear Dust Mask

16. Wear Safety Shoes

17. Wear Safety Gloves

18. Keep Door Closed

19. Gas Shut-Off

20. Eyewash

21. Safety Shower

22. First Aid

23. Fire Phone

24. Corrosion

25. No Open Flame

26. Fire Bucket

27. Fire Equipment

28. Fire Alarm

29. Standpipe Connection

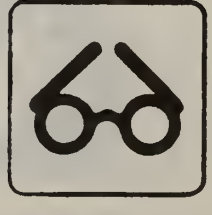
30. Sprinkler Connection

31. Water Connection

32. Respirator

33. Overhead Hazard

34. No Exit



35. Wear Safety Glasses

36. Slip

FOIL SYMBOLS FROM LIST Z

1. Flammable

2. Poison

3. Overhead Hazard

4. Slip

5. Laser

6. General Warning

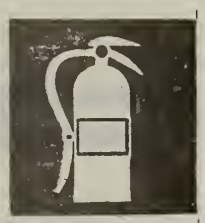
7. No Entrance

8. No Exit

9. No Entrance

10. No Smoking

11. Do Not Block



12. Fire Extinguisher

13. Wear Hard Hat

14. Wear Safety Glasses

15. Wear Respirator

16. Wear Safety Shoes

17. Wear Safety Gloves

18. Ear Protection

19. Electricity Shut-off

20. Eyewash

21. Safety Shower

22. First Aid

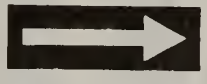
23. Explosion

24. Fork Lift

25. No Open Flame

26. Fire Ladder

27. Alarm Call Point



28. Direction

29. Hose & Reel

30. Connection

31. Connection

32. Noise Hazard

33. Electrical

34. Fall

35. Wear Goggles

36. Overhead Hazard

APPENDIX B - INSTRUCTIONS TO SUBJECTS

INSTRUCTIONS (PART A)

The purpose of this experiment is to determine how visible various picture signs are. We will be showing you many slides of picture signs, or symbols, that convey a variety of different messages. Some of these signs may be familiar to you, such as the "no smoking" symbol; others you never have seen before.

Your task is very simple: for each slide you see, you must decide whether or not the symbol indicates an exit. The majority of the signs you see will be for other messages but many will be picture signs that do stand for "exit".

Before beginning the experiment, we are going to show you some of the exit symbols so that you can become familiar with them. Take your time and look them over carefully. During the experiment you will also be seeing other exit symbols as well.

INSTRUCTIONS (PART B)

You will be viewing symbols, one at a time, through the eyepiece in front of you. Every time you push the telegraph key, you will see a red dot, which is the "ready" signal. When the red dot goes off, a slide will appear for 4 seconds. Your task is to indicate whether the symbol shown is meant to indicate the idea of "exit".

For each symbol, indicate a "yes" on the answer sheet if the sign is for an exit; indicate a "no" if the symbol is for any other message. For each slide you see you must indicate a "yes" or a "no", filling in the blanks in the answer sheet going down each column. Continue doing this until you have gone down each column and the answer form is full.

The majority of the symbols you see will be for other messages, but many do mean "exit". Some of these you have already seen, but there are others that you have not yet seen. Be sure to write a "yes" for every exit sign you see, whether or not it is one you have seen before.

We are interested in how well symbol signs can be comprehended when the visibility is very poor. For this reason, many times the symbols you see will be very faint -- in fact, you may sometimes feel that you do not see anything. It is very important that you concentrate and make your best guess. You must indicate "yes" or "no" for every slide you are shown, even when a decision is very difficult.

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5. AUTHOR(S)

Belinda L. Collins and Neil D. Lerner

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)

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10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

The performance of exit symbols was assessed in a laboratory experiment using viewing conditions degraded to resemble smoke. Research participants were presented with color slides showing symbol signs designed to be used in buildings. For each slide the participant indicated if the symbol conveyed the message of "exit." A total of 108 symbol slides were used, of which 18 were exit symbols. Each of the 42 participants were familiarized with a random set of 9 of the 18 exit symbols, prior to data collection. During the experiment, the symbol of slides were presented under three levels of viewing difficulty. In general, errors increased as the viewing conditions became more degraded but the increase in errors became much more severe for some symbols than others. Fewer errors were made for some of the symbols that had been familiarized. The data suggested that increased errors under degraded viewing conditions were related to graphic features of the symbols. A number of specific symbol features that influence exit symbol effectiveness were identified along with features of non-exit symbols that produce confusions. Finally, recommendations for exit symbol design are presented that may lessen egress-related confusions during building emergencies.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

Exit symbols; fire safety; legibility; symbols; understandability; visibility; visual alerting.

13. AVAILABILITY

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