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Visibility of Exit Directional Indicators

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Peter J. Goodin

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Abstract

A three-phase experiment assessed the effectiveness of different configurations for exit signs and directional indicators. Two phases involved visibility assessments, while a third phase was a behavioral assessment. In the experiment, sign effectiveness was determined in terms of distance to detection, correct identification, and rated effectiveness, as well as speed through a corridor. The results indicated that a chevron in grey on white with a contrast of about 0.4 to 0.5 (to meet minimum specifications) was identified correctly at the greatest mean distance and received the highest mean ratings of effectiveness, as compared to other directional indicators. The combination of a 2.25-in chevron with a 6-in EXIT sign was identified correctly at a mean distance of about 100 ft. Use of color, either red or green, increased this distance by about 15 to 20 ft. Reducing width to height ratio reduced identification distance by about 35-40 ft for chevrons of comparable height, although chevrons of 2.6 to 3.75-in. in height, with a width to height ratio of 0.29 to 0.43, were identified correctly at about 100 ft. These data suggest that chevron width could be reduced if height were increased above 2.6-in, and still maintain adequate visibility at 100 ft. However, visibility is best predicted by total chevron area, with chevrons with larger total areas seen at greater distances. Analysis of the movement data from the behavioral phase indicated that chevrons of 2.25-in provided adequate visibility at about 100 ft but that speed of movement is not a sensitive indicator for sign visibility. Finally, the data from all three phases indicate the importance of chevron size and configuration as well as sign color and contrast in determining visibility.

Keywords:

Arrows, chevrons, color, contrast, directional indicators, exit, egress, emergency lighting, sign, visibility.

FOREWORD

This report summarizes research conducted from November 1989 to August 1990, under contract with the National Electrical Manufacturers Association.

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DISCLAIMER

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1. Introduction

1.1 Background

The purpose of the present research was to determine the size at which different directional indicators, such as arrows, are visible for an exit sign at a specified distance. The National Fire Protection Association is currently revising the Life Safety Code (NFPA 101) to standardize the inclusion of a directional indicator (i.e., "arrow") with the word "EXIT". The current version of NFPA 101 (1988) specifies the use of an arrow located outside the exit legend "of such size, character and location that it is plainly visible and identifiable as a directional indicator". This wording allows arrows of any shape and size to be located below, above, and to the side of the legend - provisions which are not very specific. A proposed revision suggests the use of a 2.25-in[1] chevron (an arrow-type shape with no tail as shown in table 1) located to the left and/or right of the 6-in exit legend. Yet, it is not known whether the chevron is the best shape or whether 2.25-in is the best size for adequate visibility at 100 ft. - the maximum distance required by NFPA for locating exit signs from a means of egress. Furthermore, it is also not known whether the arrow needs to be visible at 100-ft., or at what distance an arrow is visible enough to ensure proper directional movement.

The present study is an extension of findings from previous work by Lerner (1981), Collins and Lerner (1983), Underwriters Laboratory (UL) (1988), and Young (1988, 1989) which indicated that the most visible and effective directional indicator is a chevron. The present study assessed the detectability of several arrow shapes, including a chevron, and determined their effectiveness in indicating direction. It concentrated, however, on determining the best configuration for the combination of a chevron with the exit legend. Thus, it was intended to confirm previous results about the effectiveness of chevrons as directional indicators, and determine the best size and location for combination with the word "EXIT" in terms of both visibility and egress behavior.

A three-phase study was performed. In the first, the visibility of different directional indicators and chevron sizes was assessed as a function of distance. In the second, the effectiveness of chevrons of different sizes and colors combined with the word "EXIT" in guiding people through a corridor was explored. In the third, the effectiveness of chevrons of different widths, colors, and sizes (again with the word exit) was evaluated as a function of distance.

2. Phase 1 - Initial Visibility Assessment

Phase 1 was intended to: 1) determine the distance at which directional symbols are visible

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[1] IPS units are used in the text for Exit sign and distance specification since both NFPA and UL use these as their primary units.

and effective as directional indicators; and 2) evaluate the best size and location for directional indicators relative to a six-in word legend. In phase 1, the distance at which five different arrow shapes could be detected and identified was determined for 20 observers. In addition, the visibility of six different sizes of chevron combined with a 6-in word "EXIT" was also determined for the same 20 observers.

2.1 Phase 1 Procedure

A windowless tunnel at NIST with 50 m (164 ft) of unobstructed travel space was used for phase 1. An illuminance of 1 to 2 lx was provided on the floor by incandescent bulbs located at the upper right side of the tunnel to simulate emergency lighting conditions (NFPA, 1988). The tunnel's walls were light to medium grey concrete and marked at 2 ft intervals for distance determination. The floor of the tunnel was lit to 1 to 2 lx, while the wall nearest the observer's eyes was lit to about 5 lx. The exit sign itself was located 50 m (164 ft) from the observer. The sign was externally illuminated with 54 lx (5 fc) of tungsten illumination as suggested by NFPA 101 (1988). Observers adapted to the prevailing luminance for about 5 min before the experiment began.

A total of 42 arrows, words, and a combination of both were used in phase 1. Twelve symbols (ten arrows, one EXIT, and one NO SMOKING symbol) were evaluated to determine the distance at which they could be detected (seen) and identified. Two directions (left and right) were used with five unique arrow shapes for a total of ten arrow signs. For the combination of word and directional signs, the word "EXIT" or a look-alike word "FKIT" was used to ensure that the observer read the sign and did not simply assume that any word was "EXIT". These words were combined with a chevron in one of six different sizes and four locations for a total of 28 word-directional indicator combinations. Thus, the chevron could face left or right and be located to the left or right of the word. Finally, the words EXIT and FKIT were assessed alone.

All 42 signs were reproduced at a contrast of 0.45 using grey lettering on a white background to approximate the NFPA recommended minimum for an exit sign. The set-up used to measure luminance, from which contrast was calculated, was that suggested in UL 924 (1989). The external source was located 5 ft from the sign with the photometer placed to one side, to minimize specular reflections. The grey signs were printed on matte paper, (although the red and green signs used in phases 2 and 3 were more somewhat specular). Five to sixteen luminance measures were taken for each character and averaged to calculate contrast with the background. The directional reflecting characteristics of the stroke and background were not measured. All word signs were 6-in. in height, while the symbol signs were 2.5-in. in height. When directional symbols were combined with a word legend, they ranged in size from 0.75-in to 4.25-in. Chevron direction varied randomly from left to right. Consistency was also varied with half the signs being consistent, half inconsistent. Consistency was defined as agreement between the position of and direction indicated by the chevron; e.g., a chevron located to the left of the word and pointing left was "consistent"; one pointing right was "inconsistent".

A total of 20 observers, 12 males and 8 females, all NIST employees or visitors, ranging in age from 20 to 50 were used in the initial visibility assessment. Fifteen percent were between 18 and 25; 35% were between 26 and 30; 20% were between 31 and 39; and 30% between 40 and 49. About half of the observers required some visual correction. Although the observers were relatively young, at least two observers reported visual acuity of less than 20/20. No observer reported any color deficiency. The total experimental time was about one and one-half hours but observers were advised that they could quit at any time if they became fatigued (although none did).

During phase 1, four dependent variables were assessed - distance to detection, identification, certain identification, and rated effectiveness - as a function of sign parameters including shape of directional indicator, word, chevron size, and chevron location. Detection distance represented the distance at which the observers first indicated that something was visible on the sign, although they could not necessarily say what "it" was. Identification distance was the distance at which the sign was first correctly identified, while confident identification occurred when the observers indicated they were sure of the identification. These definitions mean that detection should occur at a greater distance than identification, which in turn should be greater than certain identification distance. To obtain these data, observers (tested individually) walked forward from the starting point (164 ft from the sign) to the point at which they first detected something on the sign, where they stopped. Distance from this point to the sign was measured as an overall indicator of the detectability, not the readability, of the sign message. Observers then moved forward as necessary, stopped, identified the sign, and indicated the direction that they would turn, if any. The distance to the sign was again recorded as an indicator of the readability of the sign, and its ability to direct behavior. Observers then moved forward again, and indicated the distance at which they were sure that they could identify the sign (if they became more certain). Finally, they moved forward to a point 60 ft (18.3 m) from the sign where they rated the effectiveness of the sign on a 7-point scale. On this scale, a "1" meant "Not at all Effective", while a "7" meant "Very Effective". This measure was an indicator of the effectiveness (defined as the ability to see, recognize, read, and follow) of the individual sign to the observer. In some instances, observers had to walk beyond the rating point to identify the sign because the chevron was too small to be identified at this distance. In these cases, they returned to the rating point to make their ratings. This procedure was repeated 42 times for each observer. Each of the 42 signs was presented to the observers in random order so that they would not be able to anticipate an individual sign but would pay maximum attention to each sign. Thus, on any given trial an observer might see a directional symbol, a word plus directional symbol, a non-directional symbol, or a word alone. The same procedure was followed for each sign, even though several signs did not indicate a direction.

2.2 Results for Phase 1

Table 1 presents summary data on the visibility of exit directional indicators in terms of means and standard deviations of the distance to detection, identification, and certain

Table 1. Data on Detection, Identification and Rating Distance for Directional Indicators.

All arrows are 2.5-in, while all distances are in feet.

Sign Description		Detect	Identify	Confident	Rating	Graphic
1 Left Arrowhead With Tail	Avg	144.2	71.8	60.6	1.8	
	Std	24.0	20.8	25.9	0.8	
2 Left Chevron	Avg	130.1	92.7	76.0	3.3	
	Std	21.5	27.7	30.0	1.5	
3 Left Triangle	Avg	140.6	65.7	56.9	1.6	
	Std	24.7	19.0	20.2	0.6	
4 Left DOT Arrow With Tail	Avg	148.1	86.1	71.1	3.0	
	Std	19.5	20.1	22.0	1.4	
5 Left Arrow (Angelfish)	Avg	118.4	72.9	55.4	1.8	
	Std	32.2	30.9	22.9	0.9	
6 Right Arrow With Tail	Avg	142.2	73.0	56.2	1.9	
	Std	24.8	27.9	18.3	1.1	
7 Right Chevron	Avg	132.2	93.2	82.7	2.6	
	Std	30.3	29.3	21.7	1.4	
8 Right Triangle	Avg	123.5	64.9	51.3	1.6	
	Std	25.3	16.2	16.1	0.9	
9 Right DOT Arrow With tail	Avg	144.4	89.4	80.7	3.3	
	Std	24.8	19.5	21.1	1.3	
10 Right Arrow (Angelfish)	Avg	125.9	68.6	59.0	1.9	
	Std	30.1	16.9	24.6	1.0	
11 EXIT Symbol	Avg	138.1	28.5	28.5	1.0	
	Std	32.0	7.5	7.5	0.0	
12 No Smoking Symbol	Avg	109.1	21.3	21.3	1.2	
	Std	40.0	10.8	10.8	0.7	

identification. It also presents data on mean rated effectiveness using the seven-point scale described earlier.

Examination of the data in Table 1 for the directional indicators indicates that "something" was detected as visible on the sign between about 118 to 148 ft depending on the indicator. Correct identification occurred at much shorter mean distances -- between 65 and 93 ft from the sign. Confident identification occurred at shorter distances -- 55-83 ft from the sign.

Because the distance of primary interest for emergency egress is the distance at which a sign is first correctly identified, most of the analysis will focus on identification distance. Inspection of the data reveals clear differences between the types of directional indicators. The two chevrons were identified at the greatest mean distance (92.7 and 93.2 ft for the left and right) while the DOT-AIGA arrows were identified at means of 86.1 and 89.4 ft (left and right). The two triangles were identified at the shortest mean distances -- about 65 ft, while the arrowhead with tail and the "angel fish" were identified at mean distances between 68 and 73 ft. As might be expected, confident identification followed a similar pattern for the different indicators. These data thus indicate that a chevron by itself was visible at a mean distance of about 90 ft. Three observers identified the chevron at substantially shorter distances (about 50 ft), while three observers identified it at much longer distances (greater than 130 ft).

The pattern for rated effectiveness tended to follow that for identification distance. The least visible signs (the triangles) received the lowest mean ratings -- 1.6, while the most visible signs (the chevrons and DOT arrows) received the highest ratings (3.3 to 2.6). The data for the directional indicators (or arrows) may be compared with those for the two symbols -- EXIT and NO SMOKING. While these symbols were also 2.5-in. in height, they were much more complex visually. The result was a dramatic decrease in mean identification distance to between 21 and 28 ft from the sign with the EXIT symbol being slightly more "visible" than the NO SMOKING symbol.

Figure 1 presents another way of summarizing the data for directional indicators. In the four plots shown in Figure 1, the data are presented as boxplots (McNeil, 1977) generated by Dataplot (Filliben, 1981). In these plots, the total range is represented by the top and bottom "whiskers"; the midrange (or interquartile interval) by the rectangular box; and the median[2], not the mean as discussed previously, by the central "x". This graphical approach provides a quick summary of central tendency, variability, and outliers. Figure 1 presents boxplots of detection, identification, and certain identification distance ordered by the arrow number given in table 1. It also presents the effectiveness ratings for the ten different arrows. Inspection of these plots demonstrates generally that identification and certain identification distance in terms of median and range were greater for the two chevrons

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[2] The median is that data point for which half the data are larger and half are smaller.

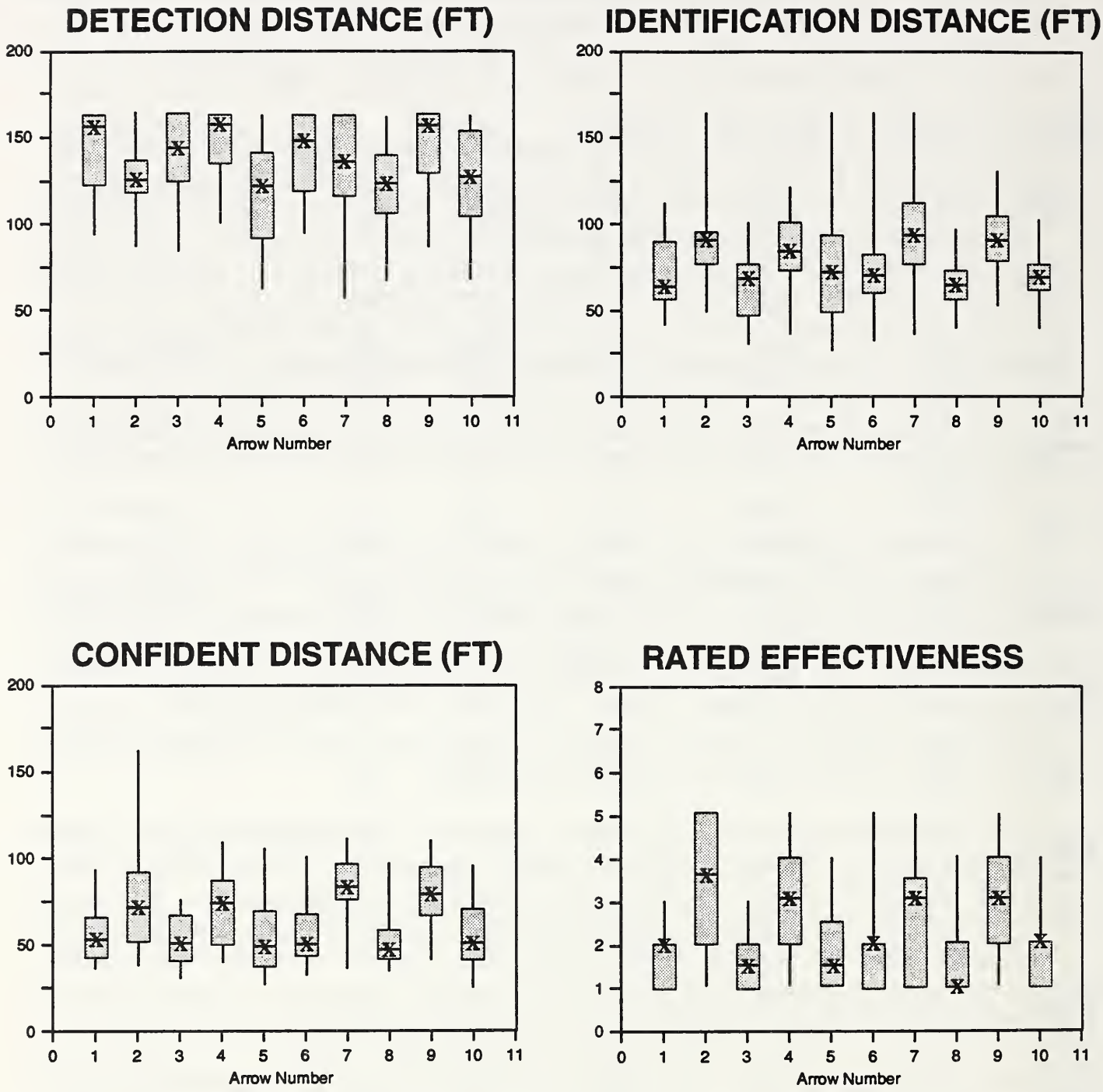


Figure 1. Boxplots of data for exit directional indicators from phase 1.

(numbers 2 and 7), followed closely by the DOT arrows (numbers 4 and 9). Furthermore, effectiveness ratings were higher for the two chevrons. While there is considerable variability about the median, analyses of variance indicated that the differences between directional indicators in both mean identification distance and rated effectiveness were significant ($p < .0001$). The data in Table 1 indicate that chevrons were identified at the longest distance with substantially shorter distances for all other arrows except the DOT arrow. A Newman-Keuls multiple comparison test also revealed significant differences in identification distance between symbols 9, 2, 7 and all other symbols.

The next set of data describes the results for the words "EXIT" and "FKIT" alone. The word FKIT was chosen to be similar in appearance to EXIT so that observers would have to read the word, rather than just assume that any four letter word was "EXIT". Inspection of Table 2 reveals that the word EXIT was identified at a greater mean distance than the word FKIT -- 146 ft versus 126 ft. Similarly, mean rated effectiveness was also greater (5.7 versus 5.1). Of interest is the fact that nine observers identified the word EXIT correctly at the maximum distance -- 164 ft. The shortest correct identification distances were 103 and 105 ft indicating that the NFPA requirement of 100 ft was effective for all 20 observers. The word FKIT was identified correctly from the maximum distance by seven people, while the shortest distance was between 61 and 63 ft.

The final set of results are for combinations of the word EXIT or FKIT and chevron. Table 2 presents these data grouped by the size of the directional indicator. Thus, the means and standard deviations for the 0.75-in indicator are presented first, followed by those for 1.0-in, 1.75-in, 2.25-in, 3.5-in, and 4.25-in chevrons. Inspection of these data suggests that the combination of the smaller chevrons with the word EXIT (or FKIT) reduced the mean identification distance substantially from that obtained for the word alone or the 2.5-in chevron alone. Thus, the mean identification distance for the word plus a 0.75-in chevron was 36 ft with a standard deviation of 13.4. The mean rating was 2.67 with a standard deviation of 1.7. The increase to a 2.25-in chevron increased mean identification distance beyond 100 ft to about 106 ft. At the same time, the mean rating of effectiveness also increased to 4.98, with a standard deviation of 1.2. Figure 2 presents boxplot data for the combination of words with chevrons of different sizes graphed as a function of chevron height. Figure 2 shows a substantial increase in identification distance, as well as confident identification distance and visibility rating, as chevron height increased at least up to 3.5-in. Figure 2 also reveals that the combination of the word plus a 2.25-in chevron was identified correctly at about 100 ft -- as specified by NFPA, with a 1.75-in chevron being identified correctly at only about 85 ft. Of interest, the visibility data (detection, identification, and confident identification) for the 3.5 and 4.25-in chevrons were nearly equivalent, indicating that both were about equally visible at 130 ft. In contrast, signs with the very small chevrons -- below 1.5-in -- were rarely visible before about 50 ft.

Analyses of variance indicated a significant difference ($p < .0001$) in detection distance as a function of both symbol shape and chevron size. The specific ANOVA models used in this report were BMDP (1989) one-way analyses on identification distance, ratings and

Table 2. Summary Data for the Combination of Words and Chevrons

Sign Description	Detect		Identify	Confident	Rating
13 6" EXIT	Mean	158.0	146.1	134.8	5.7
	Std	12.3	19.9	20.6	1.1
14 6" FKIT	Mean	157.0	125.7	115.1	5.1
	Std	12.7	34.7	37.3	1.3
15 > EXIT 0.75"	Mean	110.2	34.5	33.7	2.6
	Std	33.8	9.8	8.8	1.8
22 EXIT < 0.75"	Mean	111.6	37.3	33.3	2.6
	Std	32.5	13.6	8.3	1.8
29 < FKIT 0.75"	Mean	109.3	35.2	34.5	2.5
	Std	28.9	9.8	8.3	1.8
36 FKIT > 0.75"	Mean	117.0	38.0	34.1	2.9
	Std	29.2	18.3	7.3	1.9
16 < EXIT 1.0"	Mean	129.0	46.2	46.0	2.8
	Std	27.4	12.9	15.7	1.6
23 EXIT > 1.0"	Mean	123.1	53.6	47.5	2.8
	Std	22.5	16.1	13.0	1.2
30 > FKIT 1.0"	Mean	122.3	47.7	46.2	2.8
	Std	26.1	15.0	14.7	1.3
37 FKIT < 1.0"	Mean	119.1	56.0	49.3	2.9
	Std	23.8	21.7	16.4	1.9
17 > EXIT 1.75"	Mean	137.2	86.5	78.9	4.1
	Std	20.7	28.2	28.4	1.3

Table 2. Continued					
24 EXIT > 1.75"	Mean	143.7	89.7	79.2	4.4
	Std	19.7	24.0	19.8	0.9
31 < FKIT 1.75"	Mean	131.1	83.0	76.3	3.6
	Std	24.2	18.9	18.1	1.4
38 FKIT < 1.75"	Mean	138.9	84.4	75.7	4.9
	Std	23.2	22.5	18.7	1.0
18 < EXIT 2.25"	Mean	146.1	101.7	92.1	4.9
	Std	18.1	20.6	18.2	1.0
25 EXIT < 2.25"	Mean	152.1	114.5	103.2	5.0
	Std	18.0	27.0	26.4	4.4
32 > FKIT 2.25"	Mean	144.0	99.9	97.6	4.7
	Std	23.2	27.7	26.6	1.4
39 FKIT > 2.25"	Mean	152.6	109.3	102.9	5.9
	Std	20.3	25.4	21.5	1.1
19 > EXIT 3.5"	Mean	154.8	138.0	121.8	6.0
	Std	16.2	29.1	26.8	1.0
20 < EXIT 3.5"	Mean	155.1	138.6	130.3	5.9
	Std	16.3	24.4	22.6	1.2
26 EXIT < 3.5"	Mean	156.1	142.3	127.5	6.2
	Std	14.5	31.6	27.0	1.1
27 EXIT > 3.5"	Mean	156.5	138.6	126.7	6.2
	Std	14.5	26.9	25.6	1.1
33 < FKIT 3.5"	Mean	152.5	118.8	110.4	5.8
	Std	16.7	37.7	30.3	1.2
34 > FKIT 3.5"	Mean	152.4	128.0	118.9	5.7
	Std	20.2	31.5	28.7	1.2

Table 2. Continued					
40 FKIT > 3.5"	Mean	157.4	133.7	122.9	6.0
	Std	15.2	33.4	28.3	0.9
41 FKIT < 3.5"	Mean	158.4	129.4	120.7	5.9
	Std	11.7	28.6	25.1	1.2
21 > EXIT 4.25"	Mean	154.3	140.2	123.5	6.2
	Std	18.4	28.1	26.0	0.7
28 EXIT > 4.25"	Mean	156.7	144.7	133.4	6.3
	Std	16.3	25.3	27.7	1.1
35 < FKIT 4.25"	Mean	153.1	119.2	114.6	5.9
	Std	17.6	32.8	30.2	1.3
42 FKIT < 4.25"	Mean	155.8	127.7	116.3	5.7
	Std	17.4	32.7	28.5	1.2

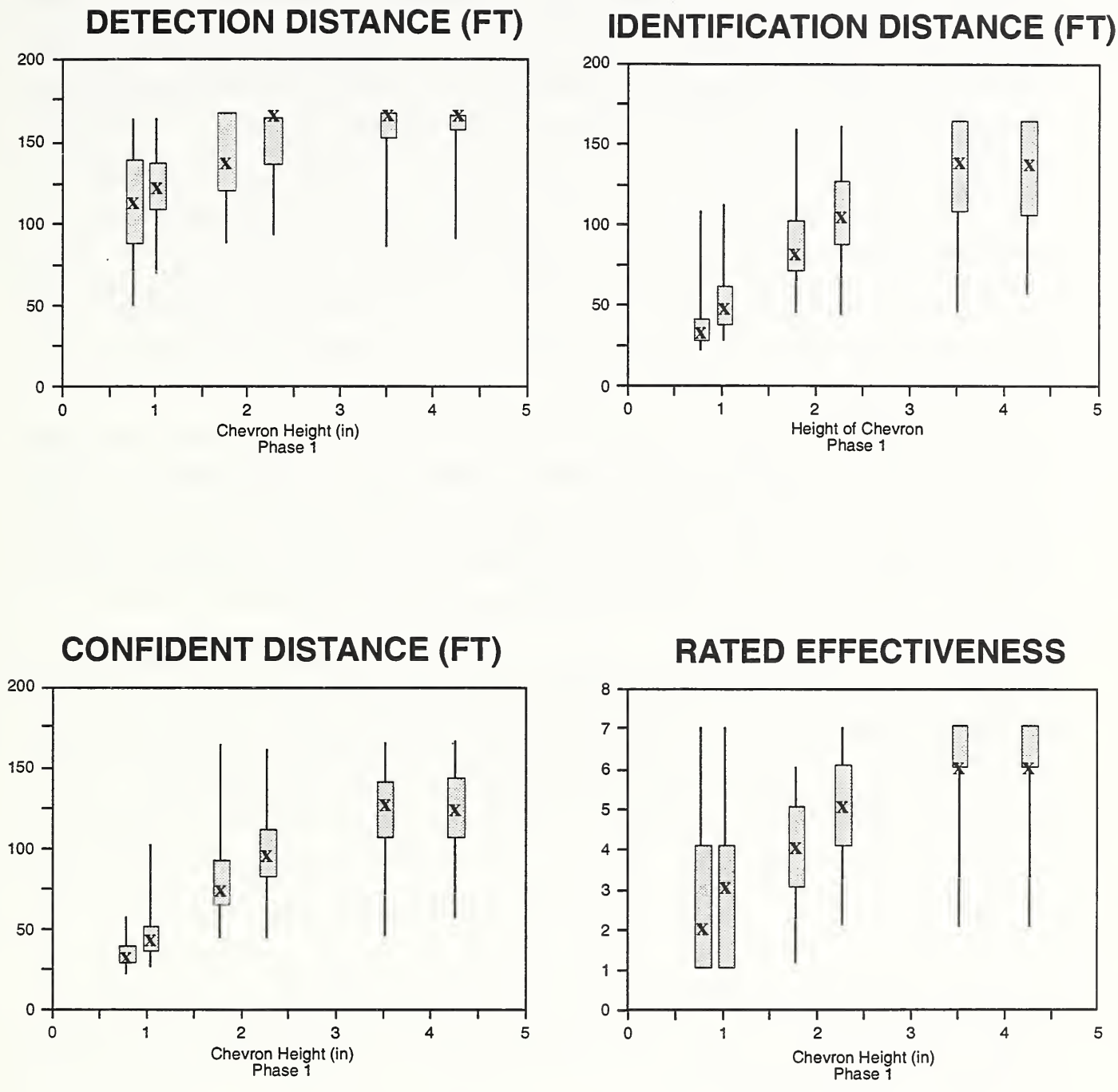


Figure 2. Boxplots of data for Exit words combined with chevrons from phase 1.

speed, and to a lesser extent, two-way analyses on specific configurations such as size and color, or size and consistency. (Some one-way ANOVAs were done with Dataplot, and repeated with BMDP.) No higher order ANOVA models were used because of lack of data in some cells - not all possible examples of all sizes in all colors were tested. These analyses were supplemented by χ^2 analyses and by multiple comparison tests such as Newman-Keuls from the BMDP program. Analyses of the differences in chevron location (left or right of the word), direction (left or right), and consistency were not significant, although there were many observer complaints about inconsistent direction. (An inconsistent chevron would be located on the left, but point right, for example.) There were also no significant differences between identification distances for the combinations of EXIT and FKIT with chevrons of different sizes. A Newman-Keuls test on identification distance as a function of size indicated that the ranges did not overlap for the 1.0, 1.75, and 2.25-in chevrons, and that the 3.5 and 4.25-in chevrons formed a fourth non-overlapping group. Thus differences between the 1.0, 1.75, 2.25, and 3.5-in. chevrons were significant. These data indicate that larger chevrons tend to receive higher ratings and be visible at greater distances.

Data from phase 1 indicate that a 2.25-in chevron was visible at 100 ft and received adequate effectiveness ratings, while chevrons bigger than this were visible at distances beyond the NFPA 100 ft requirement. Ratings of effectiveness closely paralleled the identification distance data. Frequency counts of the ratings were analyzed with a χ^2 analysis which indicated significant ($p < .01$) difference in the distribution of ratings as a function of chevron size. An analysis of variance was also significant ($p < .0001$).

All signs were rated for effectiveness at 60 ft - a distance selected for the rating data as a pragmatic compromise. When the project began there was some question as to whether 100 ft or some shorter distance was the appropriate distance from which the directional indicator ought to be seen. Tables 1 and 2 reveal that all word and directional signs were visible at 60 ft, indicating that 60 ft is an appropriate distance for rating sign effectiveness. Data on rated effectiveness thus provides information about overall sign effectiveness in addition to visibility. Problems rating the signs at 60 ft did not occur for any of the directional indicators, no matter how small, but did occur for the "exit" and "no smoking" symbols, which were not visible before about 30 ft. A comparison of tables 1 and 2 reveals that while directional indicators by themselves received low ratings, the combination of words and larger directional indicators received much higher ratings. Thus the word EXIT by itself received a mean rating of 5.7, while EXIT plus a 4.25-in chevron received mean ratings of 6.2 and 6.3 (depending on chevron direction) suggesting that the chevron actually enhanced the visibility of EXIT.

3. Phase 2 - Behavioral Assessment

In phase 2 the effectiveness of combinations of the word "EXIT" with chevrons of different size and color in guiding people through a corridor was explored using a different experimental approach. Phase 2 was a behavioral evaluation in which exit sign effectiveness was assessed in terms of number of confusions, time to identify a sign correctly, and time to move through an exit corridor. As in Phase 1, ratings of sign effectiveness were also obtained.

3.1 Procedure for Phase 2

For the behavioral assessment, a windowless corridor located in the Supply and Plant Building at NIST was used. Midway down the corridor were 2 doors, one to the left and one to the right. At the end of the corridor, another corridor was located to the left, two doors were located straight ahead, and a simulated corridor was located to the right. This configuration was intended to simulate two choice points with five possible exits. The corridor was lit at normal emergency lighting levels with three fixtures being illuminated -- at the start, midway, and the end. Illuminance on the floor varied substantially from 2 to 150 lx depending on the placement of the fixtures. Illuminance on the floor was greatest (150 lx) at the beginning and midway down the corridor, and lowest (2 lx) between fixtures. Illuminance was only 29 lx on the floor at the end of the corridor. This was done so that the greater illuminance at the first set of doors might increase the likelihood of confusions. The exit sign was illuminated to 54 lx, and located at the second choice point.

A total of 22 signs, in two groups of eleven each, was used in phase 2, although each subject saw only 11 signs (presented in random order), to reduce the time for the experiment. All signs were combinations of the word EXIT with a chevron, since the first experiment had evaluated the relative performance of EXIT and FKIT. Eight sizes of chevrons were used, ranging from 0.75-in to 2.75-in. Unlike phase 1, eight signs were red on grey, eight were green on grey, while six were grey on white. Colors were evenly divided between each group of eleven signs. Contrast was about 0.45 for the grey signs; 0.5 for the red and green signs. All signs indicated directional information, either left or right, with a mixture of consistent and inconsistent chevrons.

Thirty-four observers participated with 17 observers viewing each set of 11 signs. Each set of signs included examples of all eight sizes in the three color combinations. An additional two observers were handicapped (one walked with a limp, while the other had low-vision (20-400 in one eye) - their data are included in only a few comparisons. Sixteen observers were female; 20 were male. The majority of the observers (79%) wore some type of visual correction, either glasses or contact lenses. In terms of age, 23.5% were between 18 and 30, 20.6% between 31 and 39; 38.2% between 40 and 49; and 17.6% between 50 and 59. Finally, three observers reported mild color defects.

For the behavioral phase, observers were instructed to move through the corridor, identify the sign when they could read it, and then turn in the direction indicated by the sign when they felt it was appropriate to do so. As noted earlier, the corridor was designed with five potential exit doors to provide an opportunity for confusions and to allow the observer to select an exit path that corresponded with the directional exit sign. The exit sign was located about 118 ft from the starting point in the center of the corridor and about 6 ft above the ground. External illuminance on the sign was maintained at about 54 lx.

Observers were told that their time to move through the corridor was being recorded, but to move at their normal walking speed. Two different times were recorded - time to identify the sign, and time to move through the corridor. Measurement of time was accomplished by means of infra-red sensing devices which were activated when the observer first stepped into the corridor. A second set of sensors was located at the left and right turning points at the end of the corridor. When the observer stepped through the final set of beams, the electronic timer stopped, indicating the time to walk through the corridor in seconds. In addition, the experimenter stopped a second timer electronically when the observer identified the sign. This time was used as the basis for the identification data discussed below.

3.2 Results for the Behavioral Assessment

Several different types of results were obtained in the behavioral assessment. First, information on confusions and incorrect turns was collected. Second, the time to move through the corridor was obtained, with walking speed being determined as a function of time in the corridor. Third, information on identification distance was calculated as a function of identification time and sign distance. This procedure differs from the more direct measurement of identification distance used earlier. Finally, ratings of the effectiveness of the different signs using the 7-point scale used before were obtained, along with spontaneous comments from the participants.

The first set of data analyzed relates to confusions and incorrect turns. Data from only the first two of the eleven trials for each observer were included in this analysis since it was felt that the observers had learned the task by subsequent trials. A confusion was defined as an incorrect turn, usually at the center of the corridor or into the final set of doors located directly ahead. Analysis of the confusion data indicated that only 9 confusions occurred on the first 72 trials. Four confusions occurred for the exit sign with the 0.75-in chevron, one each for the 1.0 and 1.5-in chevrons, two for the 1.75-in chevron, and one for the 2.25-in chevron. Thus, half the confusions occurred for the two smallest chevrons, whereas only one confusion occurred for the four chevrons larger than 1.75-in. The confusions that occurred on the first two trials were relatively limited and confined primarily to the smallest arrows or to "inconsistent" arrows, suggesting that subjects could not see the signs properly, not that they did not understand the task. Thus confusions were apparently related more to not being able to see the chevron or to mistaking the direction of travel than to misunderstanding the task.

Inspection of the false positive data indicated that 14 false positives occurred in the behavioral study. These occurred when an observer said a sign faced left (or right) when it actually faced right (or left). Of the 14 occurrences, ten occurred for "inconsistent" chevrons, indicating that consistency was something expected by the observers. Eleven of the 14 false positives occurred for chevrons smaller than 2.25-in. Analyses of variance of the size and consistency factors for the rating data were significant for both ($p < .0001$), as was a Newman-Keuls test. The ratings for "inconsistent" chevrons were significantly lower than those for the "consistent" chevrons. These data indicate that consistency of placement of the chevron relative to the intended direction is important to observers. Inconsistent chevrons appear likely to result in serious errors during emergency egress.

The difference in the time required to move through the corridor for the first trial as compared with the mean time for subsequent trials was also examined. The difference between the time for the first trial and for the average of all trials was calculated for each observer using his/her own average. In 30 of the 36 cases (the two handicapped observers were included since all data were normalized to the individual), the time on the first trial was greater than the average time. It was greater by as much as 5 to 15 seconds for 12 observers. In four cases, the time was shorter than the average, and in two cases observers turned early so their time could not be calculated. An examination of the mean difference between the first trial time and the average indicates that the time generally decreased from 6.15 sec to 3.3 sec as the chevron size increased from 0.75-in to 2.75-in with anomalies in this trend for the 1.75-in and 2.25-in chevrons. Nonetheless, the use of very small chevrons consistently resulted in slightly longer travel times.

The behavioral assessment also provided information on three other aspects of the combination of EXIT signs with chevrons. These included identification distance, time to walk through the corridor and make the correct turn, and ratings of sign effectiveness. Table 3 summarizes the mean identification distance, rated effectiveness, and speed to move through the corridor for the different signs as a function of chevron size for trials 3 to 11 -- the ones for which observers were considered to have "learned" the task. The boxplot data are presented in Figure 3 for sign identification distance, time to move through the corridor, and rated effectiveness again for trials 3 to 11.

Figure 3 confirms the trends found in phase 1; namely, that signs with larger chevrons were identified accurately at longer distances. Thus the combination of a 0.75-in chevron with the word EXIT was identified accurately at a median distance of less than 40 ft, while signs with chevrons of 2.25-in or greater were identified at median distances around 100 ft. The phase 2 data yielded shorter mean identification distances than phase 1 because the total length of the corridor was substantially shorter - 118 ft as opposed to 160 ft. In phase 1, a substantial number of observers could identify the sign from 160 ft thus raising the overall average. Nvertheless, the means for the 2.25-in. green and red chevrons were close to 100 ft in phase 2. An analysis of variance indicated that the differences in identification distances as a function of chevron size were significant ($p < .0001$). The first portion of Figure 3 indicates that the use of color had an impact on overall identification distance, with

Table 3. Mean Identification Distance, Rating and Speed for Behavioral Phase

Size	Color	Identification Distance	Mean Rating	Mean Speed
0.75	Green	37.46	2.0	4.89
	Red	40.68	2.69	4.74
	Grey	35.38	1.4	4.76
1.0	Green	47.61	3.58	4.86
	Red	49.41	2.73	4.93
	Grey	39.38	2.36	4.83
1.25	Green	64.72	3.92	5.09
	Red	53.26	3.33	4.83
1.5	Green	66.09	4.33	4.89
	Red	83.96	4.71	5.10
1.75	Green	88.94	5.73	5.11
	Red	73.63	4.18	4.8
	Grey	72.87	2.71	5.24
2.0	Green	79.78	4.67	4.88
	Red	91.69	5.25	5.01
2.25	Green	104.28	5.38	5.09
	Red	96.16	5.25	5.01
	Grey	76.15	3.60	4.88
0.75	Green	96.96	6.21	4.89
	Red	100.20	5.76	5.16
(two signs used)	Grey	93.23	4.26	5.05

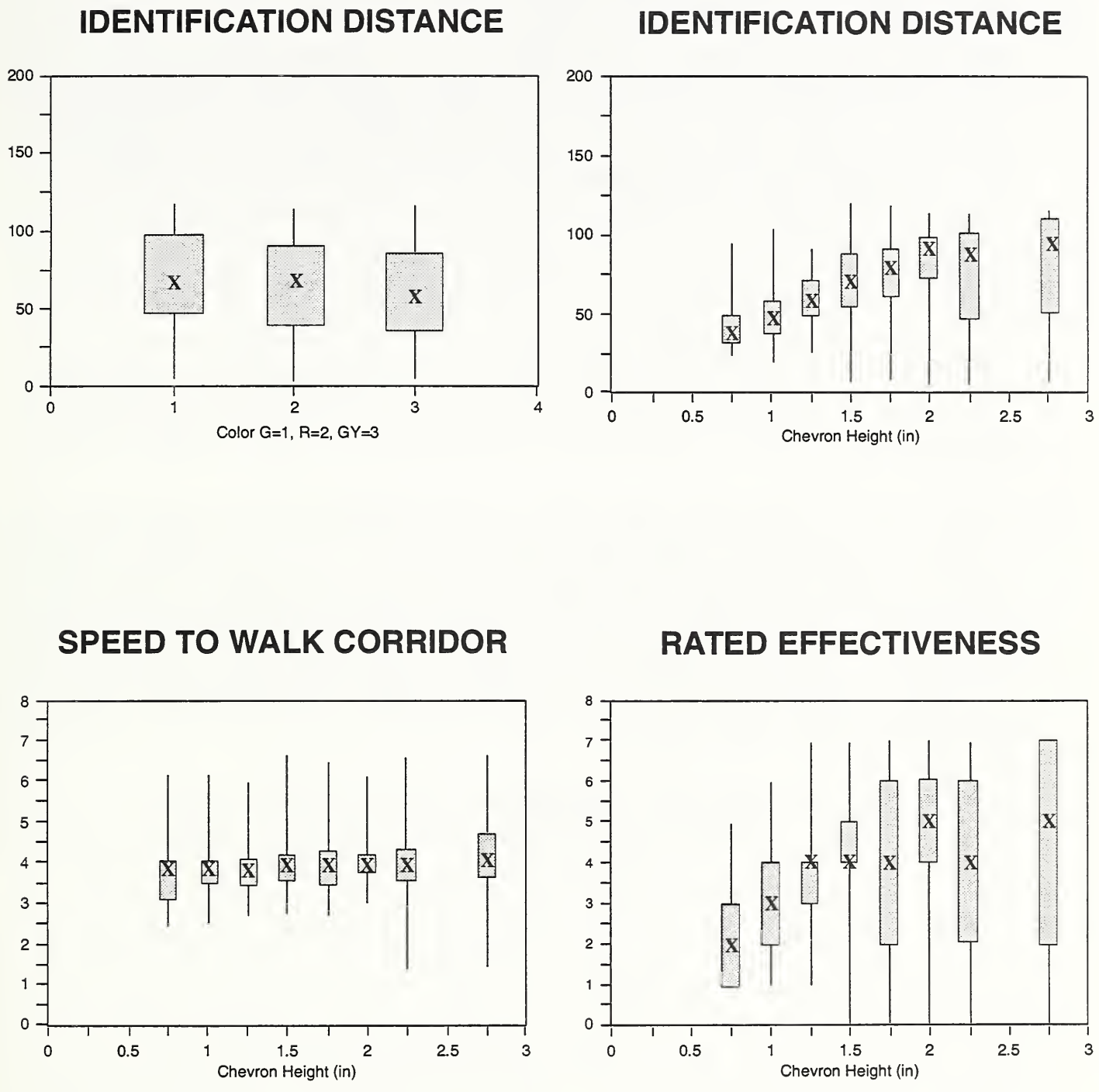


Figure 3. Boxplot of data for the behavioral assessment

red and green signs identified at greater distances than grey signs. An analysis of variance indicated that the effect of color on identification distance was significant ($p < .01$). Figure 3 also indicates that chevron size had little effect on the time to traverse the corridor - a finding confirmed by the analysis of variance.

There was a clear progression in ratings as chevron size increased when the data for the green and red signs were considered separately from the grey signs (which received very low ratings). Table 3 presents the mean data for this comparison. In fact, the rating data appear to be a more, rather than less, sensitive indicator of chevron effectiveness, in that they demonstrate a significant effect due to chevron characteristics. An analysis of variance for size was significant ($p < 0.0001$), as was a Newman-Keuls multiple comparison test ($p < .05$). Nonetheless, it is true that the identification and rating data from all phases provide more clear-cut evidence of the visibility of chevrons than do the speed data from phase 2. The behavioral data provide valuable information on confusions and inconsistencies, all of which suggest that smaller chevrons are less effective, but they do not provide evidence that chevron size affects speed in a realistic exit corridor. A way-finding experiment in which people use chevrons to find their way out of a more complicated maze might provide more conclusive evidence of slower speeds and increased confusions due to chevron size.

Finally, Figure 3 indicates that ratings of the overall effectiveness of the sign increased as chevron size increased with signs with chevrons of 2.25-in or greater receiving median ratings of 5 (on a 7-point scale), while signs with chevrons of 1-in or less received median ratings below 3. A χ^2 analysis of the difference in the distribution of the ratings for the two categories of chevrons was significant ($p < 0.05$). A χ^2 analysis of the difference in the distribution of ratings for colored (red and green) signs versus grey signs was also significant ($p < .01$). There was no significant difference in the distribution of ratings between red and green signs, however.

Table 4 summarizes the percentages of spontaneous comments made by subjects during the behavioral evaluation. The full comments themselves are tabulated in Appendix A. The following eight categories were developed to describe and group the comments: OK, not visible, too small, poor color, poor contrast, not consistent, bad design, and bad for behavior. Inspection of table 4 indicates clearly that size, consistency and color (or contrast) were important factors in subjects' perception of effective directional indicators. The signs considered to be "OK" were those with large, consistent chevrons in red or green. All the grey sign, even the ones with a 2.75-in chevron were considered to have "poor color", "poor contrast", or "poor visibility". Similarly, chevrons smaller than 1.75-in in green or red were considered to be "too small" or "not visible". Consistency between placement of the chevron and the intended direction of travel was also an important factor with inconsistent signs rarely considered to be "OK".

Table 4. Percentage of Spontaneous Comments Made During Behavioral Assessment

Size	Cons	OK	Not Vsble	Too Small	Poor Color	Poor Cntrst	Not Cons	Poor Dsgn	Bhv	N
GRAY										
0.75	Inc	0.0	38.5	23.1	7.7	7.7	15.4	7.7	0.0	13
1.00	Cons	10.0	50.0	40.0	0.0	0.0	0.0	0.0	0.0	10
1.75	Inc	0.0	0.0	9.1	9.1	27.3	27.3	27.3	0.0	11
2.25	Cons	15.4	0.0	0.0	15.4	61.5	0.0	0.0	7.7	13
2.75	Inc	7.7	0.0	0.0	23.1	38.5	23.1	3.8	3.8	26
RED										
0.75	Cons	0.0	45.4	36.4	0.0	0.0	0.0	9.1	9.1	11
1.00	Cons	0.0	9.1	63.6	0.0	0.0	9.1	18.2	0.0	11
1.25	Inc	0.0	25.0	50.0	8.3	0.0	8.3	8.3	0.0	12
1.50	Cons	7.7	7.7	38.5	7.7	15.4	0.0	15.4	7.7	13
1.75	Inc	23.1	0.0	0.0	15.4	0.0	61.5	0.0	0.0	13
2.00	Cons	10.0	0.0	50.0	0.0	10.0	0.0	30.0	0.0	10
2.25	Cons	75.0	0.0	12.5	12.5	0.0	0.0	0.0	0.0	8
2.75	Inc	41.7	0.0	0.0	8.3	8.3	33.3	8.3	0.0	12
GREEN										
0.75	Inc	0.0	0.0	45.4	0.0	9.1	18.2	27.3	0.0	11
1.00	Cons	0.0	33.3	33.3	8.3	8.3	0.0	16.7	0.0	12
1.25	Cons	0.0	18.2	54.6	0.0	9.1	0.0	18.2	0.0	11
1.50	Inc	14.3	7.1	28.6	0.0	7.1	42.9	0.0	0.0	14
1.75	Cons	66.7	0.0	16.7	8.3	8.3	0.0	0.0	0.0	12
2.00	Inc	23.1	0.0	15.4	7.7	7.7	46.2	0.0	0.0	13
2.25	Inc	36.4	0.0	9.1	9.1	0.0	27.3	18.2	0.0	11
2.75	Cons	90.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	10

4. Phase 3 - Follow-up Visibility Assessment

4.1 Procedure for Phase 3

Because the behavioral assessment had raised questions about the role of color in determining sign visibility, a third experimental phase was conducted. In this phase, 15 observers viewed 14 combinations of the word EXIT with a chevron using the same experimental procedure as the initial visibility assessment in phase 1. Observers indicated when they could detect and identify each sign, and rated it using the seven-point effectiveness scale. Six signs were the red and green signs from phase 2, two were grey on white signs from phase 1, and six were new signs designed to assess the effect of variations in chevron configuration. For the six new signs, the ratios of height to width (aspect ratio) as well as total area were varied as shown in table 5. Aspect ratio was increased beyond the 1.20 used in phase 1. Fifteen observers participated with 20% aged 18 to 25; 20% aged 26 to 30; 13% aged 31 to 39; 26% aged 40 to 49; and 20% aged 50 to 59. Ten were male; five were female. Seven required corrective lenses, and two reported mild color defects.

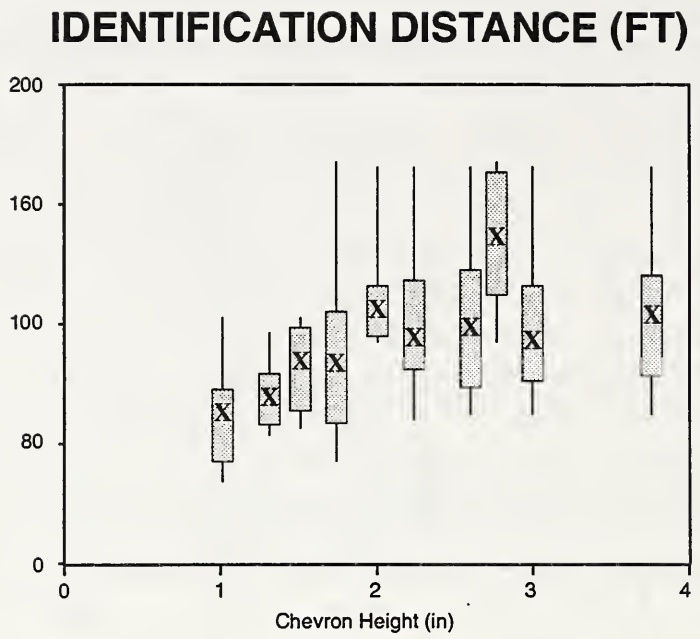
4.2 Results for Phase 3

Table 5 indicates that the mean detection and identification distances as well as effectiveness ratings increased consistently with chevron size for the red and green signs from 71 ft for a 1.3-in red sign to 136 ft for a 2.75-in green sign. Comparison with Table 2 reveals that mean identification distance and effectiveness ratings were substantially greater for the colored signs than for comparably sized grey signs. Thus, grey EXIT signs (signs 17 and 24 in Table 2) with a 1.75-in chevron were identified at 86-89 ft and given mean ratings of 4.1 and 4.4, while a similarly sized green sign (sign 110) was identified at 100 ft and given a mean rating of 5.3 as shown in Table 5. Similarly, grey signs with a 2.25-in chevron (18 and 25) were identified at mean distances of 101 and 114 ft with mean ratings of 4.9 and 5.0 while a 2.25-in red sign (113) was identified at a mean distance of 126 ft and given a much higher mean rating of 6.2.

Figure 4 presents boxplot data for detection and identification distance as well as ratings as a function of chevron height. It demonstrates that increasing chevron height did not always lead to increased identification distance or higher rated effectiveness. The upper plot in figure 5 indicates further that mean identification distance did not vary systematically as a function of chevron width. Increasing chevron height, but decreasing width was not particularly successful in increasing identifiability. Thus as indicated in table 5, the sign with the 1.75-in conventional chevron in green was identified at a mean distance of 100 ft while the 1.75-in chevron with a greater width (sign 512) was identified at only 65.7 ft (and given a mean rating of 2.7). Its performance was also poorer than that for the comparable grey on white signs (17 and 24 in Table 2) discussed above. Table 5 reveals that signs 511 and 513 (with a 2.25-in high chevrons but narrower widths and aspect ratios above 1.2)

Table 5. Visibility Data for Phase 3

	Chevron Characteristics				Observer Responses			
Sign ID	Height	Width	Area	Color	Detection		Identify	Rating
16	1.3	0.84	0.38	Grey	Mean	110.9	58.8	2.3
					Std	34.9	18.1	4.3
105	1.3	1.06	0.57	Red	Mean	130.9	71.0	4.8
					Std	33.3	13.4	1.1
108	1.5	1.25	0.75	Green	Mean	139.3	81.7	4.8
					Std	30.1	16.2	1.3
110	1.75	1.50	1.09	Green	Mean	142.1	100.5	5.3
					Std	24.1	27.1	1.2
111	2.0	1.69	1.38	Red	Mean	151.7	112.5	5.9
					Std	18.8	24.7	1.2
113	2.25	1.96	1.69	Red	Mean	151.7	126.7	6.2
					Std	22.8	27.2	1.3
17	1.5	1.50	1.09	Grey	Mean	130.9	18.1	3.7
					Std	26.3	28.1	1.5
116	2.75	2.50	2.58	Green	Mean	158.3	36.2	5.9
					Std	12.9	24.5	1.1
512	1.75	0.62	0.44	White	Mean	111.5	65.7	2.7
					Std	38.0	17.8	1.6
511	2.25	1.12	0.91	White	Mean	134.2	87.0	3.5
					Std	23.1	14.9	1.7
514	3.0	0.88	1.19	Grey	Mean	139.6	98.9	4.0
					Std	26.2	26.7	1.9
201	3.75	1.12	2.03	Grey	Mean	134.9	104.3	4.8
					Std	30.9	27.9	1.3
202	2.6	1.12	1.53	Grey	Mean	136.0	102.0	4.5
					Std	25.8	28.3	1.6
513	2.25	0.88	1.12	White	Mean	139.9	86.0	3.1
					Std	25.4	16.2	1.5



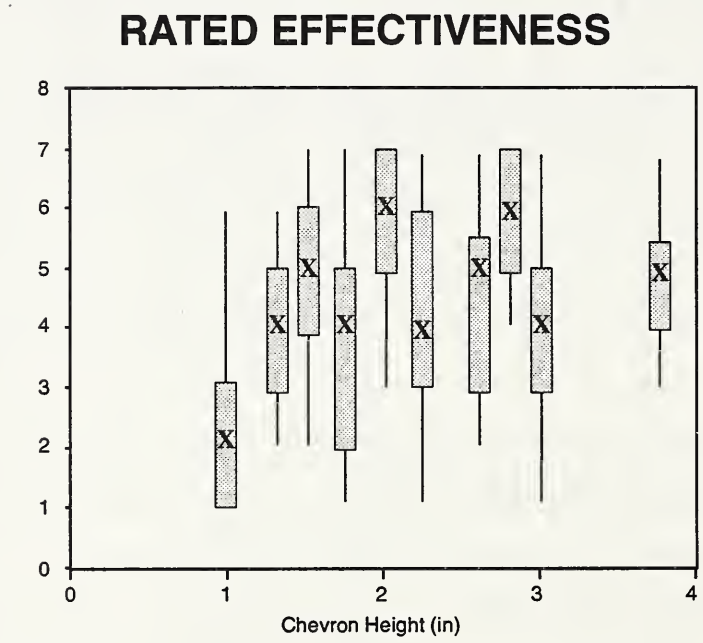


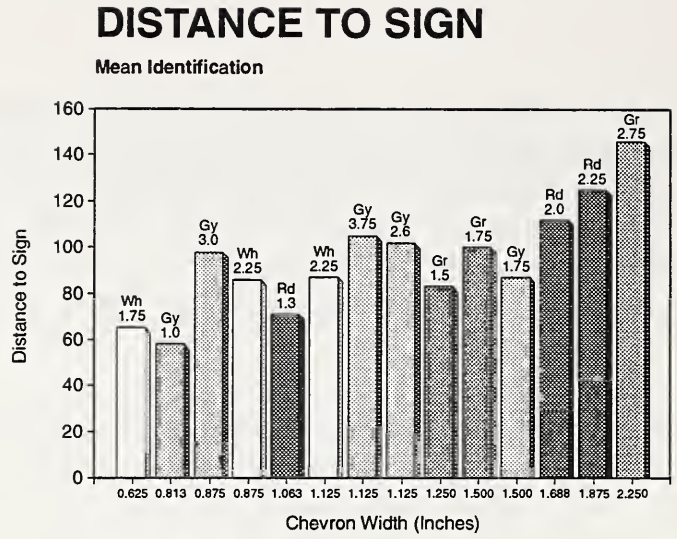
Figure 4. Box plots of identification distance and ratings as a function of chevron height for the data from phase 3.

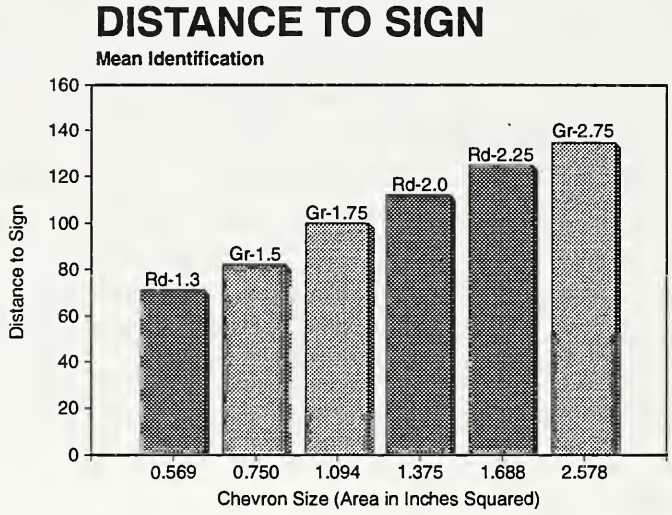
were identified at 87 ft and 86 ft (with mean ratings of 3.5 and 3.1) whereas the 2.25-in grey signs assessed in phase 1 (18 and 25) were identified at 102 and 114 ft. In contrast, the 2.25-in red sign with the same aspect ratio (1.2) was identified at about 127 ft as shown in Figure 4. These comparisons suggest that the "conventional" chevron was more effective than the one in which width was decreased. Chevron height had to be increased to at least 2.6-in, when width was decreased, to maintain visibility at the 100 ft viewing distance.

Figure 5 presents a possible explanation for this effect. In the first of these plots, no systematic relationship was revealed when mean identification distance was plotted as function of chevron width. Yet when mean identification distance was plotted as a function of total chevron area (in^2), rather than width, mean identification distance increased systematically as shown in both lower plots of Figure 5. In fact, chevron area appears to be a better predictor of sign visibility than height or width alone. Area was defined as the actual area occupied by the arrow, not the smallest rectangle. This suggests that the predictability of calculated visibility as a function of visual angle, such as presented by Howett (1983), might be improved if total area were used instead of height. The lower plots in Figure 5 compare the mean identification distance data for the red and green chevrons with that for the grey chevrons from both phases 1 and 3, and demonstrate the color effect discussed above; namely, that the green and red chevrons were visible at greater distances than the grey and white ones. Thus, to be identified at 100 ft, grey arrows required an area of 1.19 in^2, while red and green arrows required only 1.09 in^2. While there was a contrast difference (0.45 for grey versus 0.5 for color), this does not seem to account fully for the differences in visibility distance. Analyses of variance for identification distance both as a function of size and of color were significant ($p < .001$).

5. Discussion and Conclusions

Data from the three phases indicate a number of important conclusions about the visibility of exit signs and exit directional indicators. First, the chevron was the most visible indicator (followed closely by the DOT-AIGA arrow) in the present set of studies. Second, chevron characteristics such as height, width, and total area had an important influence on sign visibility, with larger chevrons identified accurately at greater distances. Third, the combination of the EXIT word with a chevron was identified at 100 ft if the chevron was at least 2.25-in high for the grey and white (0.45 contrast) configuration. If chevron width was reduced, chevron height had to be increased to at least 2.6-in for adequate visibility at 100 ft. For grey and white signs, increases in chevron size beyond 3.5-in had little impact on mean identification distance or rated effectiveness. When a red or green configuration (with 0.5 contrast) was used, however, the chevron size could be reduced. Thus, chevron sign combinations were identified at 100 ft for chevrons of 1.75-in, with little increase between 2.25 and 2.75-in chevrons in terms of either identification distance or rated effectiveness. When color was used, mean identification distance for the 2.25-in chevrons increased by about 25 ft to approximately 125 ft. Nevertheless, data from the "low vision" observer indicated that even these larger chevrons (in green or red) were visible to her only about 10 to 15 ft. before the exit sign. Her data provide some insight into the limitations





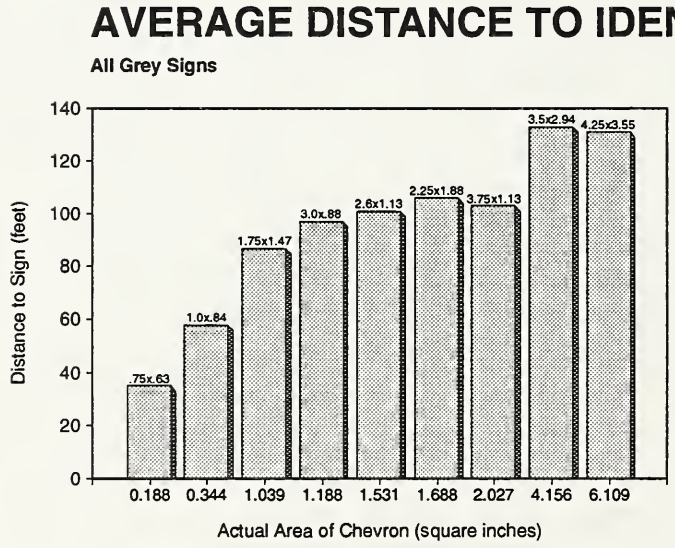


Figure 5. Mean identification distance as function of chevron width for chevrons in phase three, and as a function of area for red and green signs from phase 1, and grey signs from both phases 1 and 3.

suffered by handicapped building occupants and reinforce the need for minimum height, contrast, and color suggestions in the design of exit signs.

Questions still remain about the relative effects of color and contrast on sign identifiability, since there were differences in contrast, as well as color between the grey, red and green signs. Because the differences in contrast were small (0.1 or less), the data suggest that the use of color was an important factor in increasing sign visibility and perceived effectiveness. The behavioral data, while quite weak, tended to confirm these trends. Slower walking speeds, shorter identification distances, lower mean ratings, and more negative comments were seen in the behavioral assessment for the smaller chevrons, particularly those in grey with heights below about 1.75 or 2-in. The data also suggested that consistency in the direction of travel with the placement of the indicator was important to the observers. In the two visibility assessments, signs with a consistent direction of travel were identified at slightly greater distances and given higher ratings somewhat more frequently, while in the behavioral assessment numerous negative comments were volunteered about "inconsistent" chevrons.

The analyses of variance revealed no statistically significant difference between directional indicators pointing left or right in Phases 1 and 3, although there was a tendency for right facing indicators to be seen at somewhat greater distances. The detection distance for the large chevrons was markedly shortened in Phase 2 because the data were limited by the shorter total length of the corridor (118 ft). Because identification distances could not be greater than 118 ft, this effectively reduced the mean viewing distance below that for phases 1 and 3 where some observers identified the large chevrons at 164 ft. Identification distances obtained in phases 1 and 3 for identical signs were in fact very similar.

Finally, placement of the exit sign correctly with respect to architectural features is quite important. In the behavioral assessment people clearly expected the exit sign and attendant arrow to be located near the actual exit. The arrow was an enhancement to the sign that they considered to apply at the same location as the sign. The whole sign was perceived as an integral unit. Furthermore, observers were guided by the obvious presence of corridors and doors at the exit sign location. As a result, the behavioral assessment was not particularly successful in demonstrating a strong differential effect of variations in chevron size in creating confusions at exit choice points. Although observers successfully followed the directions given by the chevron, they expressed a desire to see the entire sign at the beginning of the corridor, and not see the chevron initially as a dot or blob near the word.

The data raise almost as many questions as they answer. For example, if contrast were increased above 0.5 or if color were used, the distance to identification would likely increase (as happened in the switch from grey to red and green signs). If internally lit signs were used, identification distance might also increase. The effects of increasing contrast, color, type and amount of illumination should be assessed parametrically in subsequent research since each of these variables appeared to influence detection distance in the present research. In addition, the data suggest that chevron height and width ratios can be varied

to meet the 100-ft visibility criterion, although chevrons with aspect ratios greater than 1.2 must be significantly taller. Further research should be done to determine the point at which varying parameters such as size, shape, aspect ratio, luminance, color and contrast no longer increase effective visibility.

Based on the data obtained from the three phases, it appears reasonable to recommend the use of chevrons with at least a 1.75 or 2.0-in minimum height and preferably 2.25-in for visibility with the word EXIT at 100 ft for signs which meet the NFPA recommended minimums for contrast. The data suggest, however, that using color (or increasing contrast) can increase the identification distance such that 1.75 or 2.0-in chevrons are visible at 100 ft. They also indicate that if chevron width is decreased, a height of 2.6-in appears to be a reasonable minimum chevron size for visibility at 100 ft.

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Appendix A. Comments Made by Subjects During Behavioral Evaluation

Sign 22 GRAY - 0.75 - Left Inconsistent	Observer Number
Too hard to see; don't know where you're going	23
Had to be at sign to see it	3
Could barely see it	19
Arrow too small	7
Too hard to see	13
Color poor, can't even hardly see arrow	25
Pitiful	29
Don't like arrow on side away from direction it points -- color, size; Arrow location all poor	15
Need 2 carets - needs darker background.	17
Dull -- Arrow too small	27
Worst yet; color very important; Arrow too small	21
Very confusing	33
No contrast; Arrow almost indistinguishable	11

Sign 16 GRAY - 1.0 - Left - Consistent	
Hard to see -- color no good -- looks like pencil	20
See exit but not arrow	8
See EXIT; can't see Arrow	26
Too light; arrow painfully small	10
Real light; couldn't see arrow until right on it	14
Nasty, poorly visible even under word; direction of travel poor	12
Arrow on correct side	28
Never saw Arrow -- cannot see an arrow at all even when right under sign	34
Hard to see arrow	36
Arrow too small, no contrast in right position	16

Sign 17 GRAY - 1.75 - Right - Inconsistent	
Colors not very bright - symbol too close to letters -- Arrow should be consistent w/direction of travel	19
Caret bigger -- wrong side -- difficult to read on white background	17
Not very legible or attention getting	15
Dim arrow; too small	21
Not a good color; confused about direction of travel	13
Arrow not distinguishable; not as vivid	11
Grey is dull -- Arrow too close to E	25
Arrow too close to E -- Arrow inconsistent	29
Poor contrast	5

Sign 17 GRAY - 1.75 - Right - Inconsistent (continued)

Don't like color at all	31
Need horizontal line with arrow	33

Sign 18 GRAY - 2.25 - Left - Consistent

Arrow bigger	28
Tried to turn into file cabinet	36
Contrast too low	16
Contrast very poor; could see arrow eventually	34
Too light	10
Color bad	18
Too dull	26
Color not as predominant	20
Size right, color doesn't catch eye	22
Grey hard to visualize	14
Directional indicator larger; visibility of whole sign poor	12
Good size	8
Not used to green	6

Sign 19 GRAY - 2.75 - Right - Inconsistent

Arrow right size -- wrong side; color poor	6
Too light; right arrow on left is bad	10
Color	20
See easily -- contrast not as great as would like	16
Closer arrow should be different color	8
Bigger; stands out; different	12
Darker	2
Bad idea to have Arrow on wrong side -- confusing	34
Arrow good	36
Not as good; fluorescent better	21
Visibility real poor even though arrow bigger	26
Red easier to see than green or black	24
Color doesn't stand out	28
Not as clear	30
Forget to turn right	32
Could not have seen if didn't know (EXIT) very poor contrast	34
Bad color - caret ok	18

Sign 26 GRAY - 2.75 - Left - Inconsistent

Need a different color	13
Dull -- confused by placement of arrow; misleading	25
Prefer arrow on other side	7
Caret bigger, but on wrong side -- color should be brighter	17
Not right colors -- more easily read	15
Poor contrast	5
Color not bright	19
Arrow big, don't like color -- not very effective	27
Needs contrast; (is too dull); doesn't grab attention	11

Sign 101 RED - 0.75 - Left - Consistent

Longest to see	22
Assume must go straight until see arrow too late	
- In emergency arrow might be overlooked	26
Exit fine, couldn't tell what direction to go	35
Arrow too small	30
Tried to go straight	10
Arrow confusing	8
Couldn't see caret	18
Arrow too small	16
Not striking -- couldn't tell when to turn	12
Arrow too close to letters	34
Arrow too small	36

Sign 102 GREEN - 0.75 - Right - Inconsistent

Arrow impossibly small	15
Not clear sign indicated direction	19
Arrow real bad	31
Good contrast in either direction	5
Want to see Arrow just as easy as exit, arrow terrible	33
Caret needs to be on other side	17
Arrow too small -- would go straight through door & not turn when I should.	
- Arrow is smaller; more difficult	11
Arrow should be bigger	12
Good color; Arrow way too small; misleading	25
Wrong arrow	29
Arrow too tiny	27

Sign 103 RED - 1.0 - Right - Consistent

Poor to see; need arrow on opposite side	33
Arrow bigger	25
Don't like color -- Arrow so small -- doesn't catch your eye	27
Exit ok; can't see arrow	11
Arrow too small	5
Exit easy -- caret too small -- wrong side -- would have to be closer to exit door	
Arrow crummy -- exit good	29
Size of Arrow	19
Size of arrow very difficult	15
Kind of lousy. Arrow important to quickly learning what to do.	21
Prefers bigger arrow; easy color to see	13

Sign 104 GREEN - 1.0 - Right - Consistent

Arrow too small	30
Red more outstanding	22
Like darker color -- arrow misleading	26
Pretty bad	24
Small	6
Size of Arrow no good	18
Color great -- Arrow very ineffective	28
Long time to find Arrow	34
Couldn't tell until right up on it	16
Arrow blends into nothing	4
Not as striking; indicator doesn't show up	12
Arrow too small -- have to be right on top to see it	14

Sign 105 RED - 1.25 - Right - Inconsistent

Arrow too small	8
More red -- Arrow hard to distinguish	36
Can't tell which way to go until approach arrow	12
Arrow makes me blind	28
Couldn't see directional signal -- too late	22
Arrow too small and on wrong side	14
Color good -- Arrow too small, on wrong side	16
Little arrow	20
Poor direction	6
Arrow no good	32
Arrow small	8
Arrow small; not as light	10

Sign 106 GREEN - 1.25 - Left Consistent

Arrow too small & close to letters	25
Arrow too small	15
Arrow too small color selected very important -- should go w/space around it; Green stands out better here because of yellow and red in space near it	21
Seemed darker	27
Needs larger caret or more than one	17
Arrow is the pits	29
Still poor	33
Arrow not big enough	11
Harder, poorer arrow	7
Arrow hard to see	19
Little arrows hard to see	23

Sign 107 RED - 1.5 - Right - Consistent

Not as clear	13
No tail	33
Terrific EXIT, better arrow	29
Prefer bigger arrow	7
Not sure what to do	3
Arrow not as clear	15
Best to have bigger arrows	5
Arrow small; doesn't stand out; EXIT ok	25
Arrow not as distinguishable as others	11
Too small	19
Bright -- not quite as effective	27
Needs larger caret	17
Don't read red very well	21

Sign 108 GREEN - 1.5 - Left - Inconsistent

Arrow has to be much larger -- position of Arrow counter-intuitive	16
Green better than red	28
Not that visible; green not striking	12
Like green arrow; easily seen	36
Arrow too small	32
Arrow too tiny	10
Arrow on right should not point left	6
Confused	24
Arrow too small; not visible enough	8
Confusing	35
Arrow no good	20

Sign 108 GREEN - 1.5 - Left - Inconsistent (continued)

Poor contrast -- Arrow on right pointing left causes big problems - in wrong place	34
Arrow wrong side	14
Other side	2

Sign 109 RED - 1.75 - Right - Consistent

Arrow pointing left, but on right	28
Color, size good	6
Arrow easier to distinguish	36
Black more visible than red	26
Green stands out better, not classically connected with emergency	16
Directional no good -- on wrong end -- inconsistent	18
Arrow clear	34
Opposite side - left should be on left	24
Arrow on wrong side	20
Arrow on wrong side	14
Confusing -- because on wrong side	8
Would go to sign and take a left at corridor	12
Confused by arrow	2

Sign 110 GREEN - 1.75 - Right - Consistent

Arrow is consistent with direction of travel	11
Bright	27
Green may be better	9
Likes green	3
Green better than red -- bigger arrow better	31
Has gotten used to carets	19
Real clear; different than red	7
Size of arrow -- too small, hard to read in a panic	15
Green on arrow more difficult	17
Big enough to see	13
Arrow could be bigger	5
Dull, couldn't see arrow	25

Sign 111 RED - 2.0 - Left - Inconsistent

Liked green arrow marker too small	31
Arrow not as good as other	29
Be clearer	3
Arrow not distinguishable at rating point	11
Used to red, pay more attention	25

Sign 111 RED - 2.0 - Left - Inconsistent (continued)

Prompt sign is not a description of proper arrow	19
Arrow marginal	15
Not as big as others	13
Easier to read -- caret bigger or doubled	17
Like color -- Arrow a bit small	27

Sign 112 GREEN - 2.0 - Right - Inconsistent

Color better -- Arrow on wrong side	20
Arrow larger but on wrong side	16
Good sign -- arrow in wrong place -- confusing	8
Arrows too small	32
Arrow needs to be on same side as direction	10
Less contrast, color poor. Left side seems harder to see.	34
Carets bigger	18
Easy to visualize -- good color	14
Color good -- arrow on wrong side	6
Like green color	36
Arrow so small compared w/EXIT	26
Green may be brighter	12
Arrow in wrong place	35

Sign 113 RED - 2.25 - Right - Consistent

Red not as easy as other two colors	36
Red; can see arrow well	12
Arrow bigger, consistent color better	34
Like larger Arrow, color contrast could be greater	16
Arrow bigger	10
Caret bigger	18
Red good; Arrow bold	22
Arrow bigger; even better if black	26

Sign 114 GREEN - 2.25 - Left - Inconsistent

Could see it -- would have preferred red	19
Brighter, clear	21
Prefer arrow on other side	7
Not right color, but visible	15
Arrow not what people are used to seeing	11
Real good	25
Arrow should be on same side as you're going to -- need Arrows that look like arrows	17

Sign 114 GREEN - 2.25 - Left - Inconsistent (continued)

Beautiful -- one of best	29
Wants bigger arrows	5
Doesn't know if arrow should be on side of direction indicated	9
Wants tail on arrow	33

Sign 115 RED - 2.75 - Right - Inconsistent

Arrow should be on side in which you turn	23
Arrow too close to letters	25
On right -- telling you to go left	11
Nice & bright -- larger arrow	27
Because of size of arrow	19
More visible	15
Good one for reading	13
Jumps out at you to turn the wrong way	29
Green best	21
Legible, easy to read, know direction	17
Good size arrow; contrast is not as good as with green	5
On opposite side -- arrow on wrong side	7

Sign 116 GREEN - 2.75 - Left Consistent

Best of all so far	26
Likes bigger arrow better	10
Very effective, prefer red	16
Read very easily	36
See arrow; color better, but not better than red	20
Better -- bigger can see earlier	30
Don't like green signs - would be "7" if red	18
Would prefer different arrow; a bit bigger	6
Good, best so far	28
Size, color, stands out	12

General Comments made by the Observers

- Prefers Red signs
- Arrow should be consistent w/direction of travel
- Need arrow where decision needs to be made

- Sign should give information before you're right up on it -- e.g., hazardous material -- would like directional information -- give full information at starting point.

Comments Continued

- Size of arrow is the big thing in seeing the sign. As soon as someone hits a corridor, they should know which way to go, especially in a fire.
- Had problems with size of Arrows; thinks that when you see EXIT, you expect to know the direction at same time. Prefers to know both; makes him more comfortable. You may not need to know it all the time, but you may really need it in a fire.

- Direction is important. The larger arrow, the better. It should be consistent with direction of travel.
- May be good to have smaller Arrows -- follow sign in emergency but 0.75-in. too small, perhaps need several arrows -- still would like to see arrow at same time as exit, more likely to see under adverse conditions. May need to use a number of arrows. Arrow should be consistent with direction of travel.

- Instead of caret -- prefer tail to arrow -- prefer consistency w/direction of travel -like arrow to be as big as possible.
- In emergency situation you shouldn't have to worry about where arrow is -- something more solid looking than current arrow -- need bold arrow.

- Red catches eye better; size of arrow should be larger
- Don't like black ones; Arrow consistent w/direction of travel -- red stands out better.
- See dot before arrow; see red better than green or black.
- Red seems brighter; more grabbing than green or grey -- green w/big arrow good. (Subject was slightly color defective)

- Good to have Arrow on side that it's pointing to and be bigger.
- Darker better; Arrow must be bigger, wider, heavier & sharper
- Side arrow is on is confusing unless consistent; color important; size important.

- Green catches attention because unfamiliar and stands out -- Arrows need to be bigger.
- Fire service experienced. Wants tails on arrow -- tail on E helps. Wants arrow under or above EXIT word, not at end.

- Low Vision subject (20-400 right eye; finger count left eye). Red better than green; bigger Arrows better; consistency of direction of travel important.

- Subject had slight color deficiency; Wants arrow to be same size as letters; put arrow in direction consistent w/direction of travel -- make Arrow larger -- want bigger arrows in black perhaps.

- Likes green and grey better than red.

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A three-phase experiment assessed the effectiveness of different configurations for exit signs and directional indicators. Two phases involved visibility assessments, while a third phase was a behavioral assessment. In the experiment, sign effectiveness was determined in terms of distance to detection, correct identification, and rated effectiveness, as well as speed through a corridor. The results indicated that a chevron in grey on white with a contrast of about 0.4 to 0.5 (to meet minimum specifications) was identified correctly at the greatest mean distance and received the highest mean ratings of effectiveness, as compared to other directional indicators. The combination of a 2.25-in chevron with a 6-in EXIT sign was identified correctly at a mean distance of about 100 ft. Use of color, either red or green, increased this distance by about 15 to 20 ft. Reducing width to height ratio reduced identification distance by about 35-40 ft for chevrons of comparable height, although chevrons of 2.6 to 3.75-in. in height, with a width to height ratio of 0.29 to 0.43, were identified correctly at about 100 ft. These data suggest that chevron width could be reduced if height were increased above 2.6-in, and still maintain adequate visibility at 100 ft. However, visibility is best predicted by total chevron area, with chevrons with larger total areas seen at greater distances. Analysis of the movement data from the behavioral phase indicated that chevrons of 2.25-in provided adequate visibility at about 100 ft but that speed of movement is not a sensitive indicator for sign visibility. Finally, the data from all three phases indicate the importance of chevron size and configuration as well as sign color and contrast in determining visibility.

12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)

arrows; chevrons; color; contrast; directional indicators; exit; egress; emergency lighting; sign; visibility

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