ELSEVIER

PII: S0003-6870(96)00063-4

Applied Ergonomics Vol 28, No. 3, pp 181–187, 1997

0003-6870/97 $17.00 + 0.00

Effectiveness of elevator service signs: Measurement of perceived understandability, willingness to comply and behaviour

Michael S. Wogalter,[1] Paul B. Begley,[1] Lori F. Scancorelli[1] and John W. Brelsford[2]

[1]*Ergonomics Program, North Carolina State University, Department of Psychology, Poe Hall, Raleigh, North Carolina 27695-7801, USA*
[2]*Human Factors Program, Rice University, Department of Psychology, Sewall Hall, Houston, Texas 77251, USA*

(Received 16 August 1996)

This research examines the effectiveness of four elevator service signs. The signs' purpose is to reduce delays for longer distance riders by dissuading people from using the elevator when they are only going up one floor or down two floors. Three of the four signs were described in Chapanis' (1965, *Human Factors* 7, 1–17) seminal treatise entitled 'Words, words, words...': an original sign and two others that he suggested as possibly being better. The fourth was an enhanced sign incorporating human factor principles that were derived from research since Chapanis' article. The enhancements involved the use of colour, a signal word panel, icons/pictorial, and direct, explicit wording of the required behaviour. In Experiment 1, participants rated the understandability of each sign and their willingness to obey its instructions. The pattern of the means was the same for both questions. The original sign was rated lowest and the enhanced sign was rated highest, with the two other signs receiving intermediate ratings. In Experiment 2, the signs were placed on each floor of six multi-story buildings adjacent to the elevator call buttons. People's use of the elevators during the posting of each sign and during no-sign (control) periods was measured. The experimenter rode the elevators and counted the total number of passengers using the elevators as well as the number who rode up only one floor or down one or two floors (noncompliers). The new enhanced sign increased compliance compared to the other three signs and the no-sign period. These results suggest that design principles derived from recent research can help to promote comprehension, motivation and compliance behaviour to signs. © 1997 Elsevier Science Ltd

Keywords: warning, signs, instructions, comprehension behaviour, compliance

Introduction

In his 1964 presidential address to the Human Factors Society, entitled 'Words, words, words...,' Alphonse Chapanis suggested that organized research involving the words and language of ergonomic systems was a badly-neglected, though a potentially compelling domain of study (Chapanis, 1965). Chapanis noted that sometimes modifications in 'words and language' in ergonomic systems could enhance human–machine interactions to a greater extent than changes in 'engineering' features.

Chapanis' assertions about the importance of words and language in ergonomic design and research has had substantial impact. A casual glance at the professional human factors/ergonomics research journals or meeting proceedings over the past three decades leaves little doubt that the field has become intensely focused upon words and language as a critical tool to benefit people's performance, satisfaction and safety. There has been a trend towards research emphasizing attention, encoding, comprehension, memory, attitudes, beliefs, behavioural intentions and behavioural compliance to the instructions on product labels and other kinds of documentation (Laughery *et al*, 1994). Modern human factors research and design efforts are frequently directed to finding and designing optimal ways of communicating procedural and conceptual information. The direction of these investigations indicates that many of Chapanis' suggestions have taken root in ergonomic design and research.

One of the language-related areas that has become well-established in recent years is research on the effectiveness of warnings and other kinds of signage (Wogalter *et al*, 1987). Studies have focused on ways to make warning signs attention getting, comprehensible, easily remembered, and elicit behavioural compliance. Previous research suggests that many kinds of posted signs are ineffective because they fail to attract people's attention, they are not understandable and they fail to motivate people to comply. For example, Young and Wogalter (1990) found increased knowledge of product manual warnings when the salience of the warnings was increased by adding colour highlighting, by enlarging and bolding the print, and by including pictorials compared to warnings without these features.

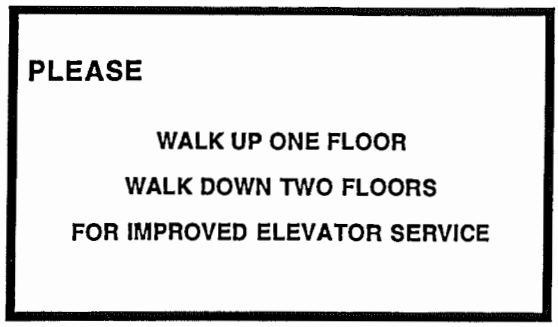
One of the most well-known sections of 'Words, words, words...' is a vivid discussion under the heading 'Confusion at the elevators'. This confusion involves a sign that Chapanis saw in the corridor of a large Baltimore hospital (Sign A in *Figure 1*). The purpose of the sign is to dissuade people from tying up the elevators when they are only going up one floor or down two floors. The goal is to lessen the delays of riders who need to travel between distant floors by reducing the amount of stopping by riders taking very short trips. As Chapanis (1965) put it: the sign had instructions which did not instruct and directions that did not direct. Chapanis offered two other signs (Signs B and C in *Figure 1*) as possibly being better. One is a longer version which he believed would improve comprehension over the original. The other (Sign C) is a briefer version of sign B but Chapanis expressed concern that it might not be understood as well as the longer revised version (Sign B). Although the improvement over the original seems apparent from looking at the two revised signs, Chapanis provided no data-based empirical confirmation of his assertions, nor has any data been reported by other researchers since these signs were described more than 30 years ago. In the present research, we do these tests.

Additionally, as there has been a great deal of research on warnings and signs in recent years, it seemed appropriate to compare these three elevator signs to another sign containing feature enhancements based on principles derived from human factors/ergonomics research published since Chapanis (1965). This enhanced sign (sign D in *Figure 2*) was developed to facilitate attention, attraction, understandability and compliance by incorporating the components of colour, a signal word, icons and pictorials, and direct, explicit behavioural directives—which individually have been found to benefit warning effectiveness measures (e.g. Friedmann, 1988; Laughery *et al*, 1993; Wogalter *et al*, 1987; Young and Wogalter, 1990).

Experiment 1 measures perceived understandability of and willingness to comply to the three signs described by Chapanis as well as an enhanced sign that was constructed based on recent ergonomics research. Experiment 2 measures behavioural compliance to these same signs.

Experiment 1

Participants rated the understandability and their willingness to obey the instructions of each of the four signs.



Sign A

Sign B

Sign C

Figure 1 The three signs from Chapanis (1965). The first (sign A) is the original sign used in a Baltimore hospital. The latter two signs (B and C) are revisions suggested by Chapanis as possibly being better than the original

Method

Participants. Fifty-nine undergraduate students from North Carolina State University between the ages of 18 and 29 were surveyed. This sample included 41 males and 18 females. They were given research credit for an introductory psychology course.

Materials. Signs A, B and C were constructed to represent as closely as possible the original signs used by Chapanis (1965). They were produced using a bold 18- to 48-point san serif proportional font that was laser printed onto 21.6×27.9cm (8.5×11inch) white sheets in landscape orientation (width longer than height). Sign D was created using principles known to facilitate attention capture, comprehension and behavioural compliance. Enhancement features included the use of a signal-word panel (i.e. the term

Sign D

Figure 2 An enhanced sign (D) revised based on characteristics found in research to facilitate sign effectiveness

NOTICE on the upper section of the sign), icons (i.e. up and down arrows), a pictorial (i.e. a human figure using the stairs), and direct, explicit wording of the required behaviour (i.e. telling people to use the stairs, rather than telling them to 'walk') and a concise statement of the consequences of compliance (i.e. better elevator service). In this experiment, all signs were in black and white. (Sign D was in color in Experiment 2.) Sign D was printed in portrait orientation (height longer than width).

Four booklets were assembled containing all four signs; each was ordered differently according to a balanced Latin square. The first page of each booklet contained a brief set of instructions. Separating the sign pages were sheets that were completely filled with random alphanumeric characters. These sheets were inserted to prevent participants from previewing ensuing booklet pages.

A response sheet contained two rating questions and had blanks for participants to mark their answers. Ratings were made using a nine-point Likert-type scale ranging from 0 to 8. The first question asked 'How understandable is this sign?' and had the following numerical and verbal anchors: (0) not at all understandable, (2) somewhat understandable, (4) understandable, (6) very understandable and (8) extremely understandable. The second question asked 'How willing would you be to obey the instructions on this sign?' and had the following numerical and verbal anchors: (0) not at all willing, (2) somewhat willing, (4) willing, (6) very willing and (8) extremely willing.

Procedure. Participants were tested in small groups. One of the four elevator-sign booklets and a response sheet were distributed to each participant. Then, the experimenter read aloud a set of instructions that noted (a) they should rate each sign on the two questions before turning to the next sign, (b) they should rate the signs in the order that they appear in the booklets and (c) they should not preview later pages in their booklets or refer back or change their ratings to the signs on earlier-viewed signs. After participants completed their evaluations, the experimenter asked them to turn over their response sheet and write out as completely as possible their interpretation and purpose of the signs. Lastly, the materials were collected and the participants were debriefed, given research credit and thanked.

Results

Table 1 presents the means for both questions (understandability and willingness to comply) as a function of the sign condition. Both items produced the same pattern: the enhanced sign D had the highest ratings followed by sign B, then C, and lastly by sign A.

Separate one-factor repeated-measures analysis of variance (ANOVA) were applied to the understandability and willingness to comply scores; both were significant, $F(3, 174) = 48.86$, $MS_e = 3.25$, $p < 0.0001$, and $F(3, 174) = 34.49$, $MS_e = 3.06$, $p < 0.0001$, respectively. Paired comparisons among the means using the Newman–Keuls multiple-range test showed all differences between the signs are significant for both measures ($p < 0.01$).

Because we used a balanced Latin square and controlled the signs' exposure order, the order can be analyzed as a between-subjects factor in a mixed-model ANOVA with sign condition as the within-subjects factor. For the understandability ratings, this analysis showed a main effect of sign condition (the specifics of which were described earlier), $F(3, 165) = 59.68$, $MS_e = 2.72$, $p < 0.0001$, but there was no significant main effect of order, $F(3, 55) = 2.27$, $MS_e = 7.95$, $p > 0.05$. However, there was a significant sign × order interaction, $F(9, 165) = 4.90$, $MS_e = 2.72$, $p < 0.0001$. Simple effects analysis showed that the pattern of sign means was consistent across all orders except for sign C. When presented first ($M = 1.75$), sign C was rated significantly lower than at the other three positions ($M = 4.60$, 4.64 and 5.56 in the second, third and fourth positions, respectively).

Similarly, the mixed-model ANOVA on willingness to comply showed a significant main effect of sign (described earlier), $F(3,165) = 42.22$, $MS_e = 2.54$, $p < 0.0001$, but no significant main effect of order, $F(3,$

Table 1 Ratings of understandability and willingness to comply to the four signs

Rating	Sign condition			
	A Original	B Revised—long	C Revised—short	D Revised—enhanced
Understandable	2.88	5.71	4.20	6.59
Willing to comply	2.36	4.53	3.34	5.41

55) < 1.0. However, there was a significant sign × order interaction, $F(9, 165) = 5.07$, $MS_e = 2.54$, $p < 0.0001$. Like the understandability ratings, simple effects analysis on the willingness to comply data showed a consistent pattern of means for all signs across the different orders except for sign C. When sign C was presented first ($M = 1.14$), willingness to comply was lower than at the other positions ($M = 3.33$, 4.43 and 4.31 for the second, third and fourth positions, respectively).

Two judges scored the responses to the final question which asked participants to describe the meaning of the signs. All (100%) of the participants understood the intended meaning at the end of the experiment.

Discussion

This study substantiates Chapanis' assertion regarding the elevator signs described in his 1965 article. Both of the revised signs that he suggested were rated significantly higher in understandability than the original sign. Also, the present study confirms Chapanis' uncertainty with regard to sign C's adequacy compared to sign B. Sign C, although briefer, lacks the parenthetical statement of consequences present in sign B. Sign C was rated less understandable than sign B indicating that the consequences statement increased participants' perceived understanding and willingness to comply. Another indication of sign C's reduced effectiveness was revealed in analyses which considered the signs' order of appearance in the booklets. When this sign appeared first, it received much lower ratings compared to its presentation later in the booklet. This result suggests that sign C by itself does not provide enough information for people to understand it. Only when one or more of the other signs preceded sign C did participants begin to understand its intent.

The results also showed that the newer, enhanced sign (sign D) that included a signal word panel and icon, pictorials and explicit consequences produced higher evaluations than the three other signs. This finding confirms research published since the Chapanis (1965) article showing the individual benefits of these features in warning signs.

Although these results may seem to give compelling support for Chapanis' assertions, they can not be considered adequate in themselves. The reason is that subjective responses are not always reflective of behaviour. Since the main purpose of the sign is to influence behaviour, it is important to verify rating evaluations with measurement of actual compliance. This is the purpose of Experiment 2.

Experiment 2

The same four signs used in Experiment 1 were posted adjacent to elevator call buttons in multi-storey buildings. During specific constant durations, the number of individuals who rode the elevators and who failed to comply were recorded. Control periods (no-sign) were interspersed between the sign conditions as well as before and after the sequence.

Method

Participants. All riders using the elevators during the measured time periods were included with the exception of handicapped individuals and individuals carrying or rolling large, heavy objects as they are not the targeted population ($N = 791$).

Materials and buildings. The signs in this experiment were identical to those used in Experiment 1 except that sign D was multi-coloured. The panel enclosing the signal word NOTICE was green and internal space of the arrow icons, and the numbers '1' and '2' were coloured red. All signs were plastic laminated to ensure durability.

Data were collected for six buildings with elevators in Raleigh, North Carolina. Four were academic buildings on the campus of North Carolina State University and two were office buildings in downtown Raleigh. Each building had six to eight floors. Buildings were chosen partly based on the location of the stairwell relative to a single elevator in the area; the location of stairs had to be conspicuous (usually immediately adjacent to the elevator) in order to minimize the cost of complying to the sign. In other words, finding and using the stairs was relatively easy (Wogalter *et al*, 1989).

Procedure. The experimental procedure was composed of a series of nine, alternating 15-min time blocks. Each of the four signs was shown in one of the four blocks. The other five blocks were the no-sign baseline (control) periods: the first and last block as well as the blocks separating the sign blocks. A schematic timeline of the 135-min sequence is shown below:

|baseline|sign|baseline|sign|baseline|sign| baseline|sign|baseline|

During sign blocks, one of the four evaluated signs was posted in a location immediately above the elevator call buttons on every floor of the building. During the entire 135-min data collection period, the experimenter rode the elevator and recorded the total number of passengers and the number who either rode up only one floor or down only one or two floors. Measurement of elevator use during each sign's posting and during the five no-sign (baseline control) periods was used to produce a set of operationally-defined proportions of noncompliance and compliance.

Six sign posting sequences were used. Four were based on a balanced Latin square design and two were randomly generated orders. These orders were randomly assigned to the six buildings. For example, if a building was assigned the order D, C, A, B, the sequence would be as follows: baseline 1, sign D, baseline 2, sign C, baseline 3, sign A, baseline 4, sign B, baseline 5.

Results

Participants who rode up only one floor, or rode down one or two floors were considered to have failed to comply (or in the case of the no-sign/baseline condition to have performed the undesired behaviour that was considered noncompliance). These individuals were given a score of '0'. Individuals who rode the elevator

for longer distances were given a score of '1'. Higher proportions indicate greater compliance.

Analysis progressed in three stages. The first stage was to determine whether the building location interacts with sign/baseline conditions. If it does, then this result would mean the relative effectiveness of the sign conditions is not consistent across locations. To examine this possibility, a 9 (sign/baseline periods) × 6 (buildings) between-subjects ANOVA was performed. Although ANOVAs are not usually the preferred method to analyze dichotomous data, Cochran (1950) concluded that ANOVA is a valid, reasonably robust test of binomial data. In this initial stage of analysis, it is used as a way of examining the simultaneous influence of sign and building. The ANOVA showed that the interaction was not significant, $F(40, 737) < 1.0$, indicating a consistent pattern of compliance rates for the sign/baseline conditions across all of the buildings. Given the lack of sign/baseline × building interaction, the data are collapsed across buildings in subsequent (second and third stage) analyses.

The ANOVA also showed a significant main effect of building, $F(5, 737) = 13.14$, $MS_e = 0.179$, $p < 0.0001$. This result is not unexpected and simply means that the levels of compliance differed at the different buildings (with buildings 1–6 having proportions of compliance and totals as follows: 0.88 ($N = 216$), 0.77 ($N = 79$), 58 ($N = 61$), 0.87 ($N = 159$), 56 ($N = 136$) and 0.60 ($N = 140$), respectively. This building effect might be due to multiple factors such as the varied configuration of the buildings and the characteristics of the individuals who frequent the locations. It is also not surprising to find that different numbers of people used the elevators at the different locations. The buildings were of different sizes, used in different ways (academic and residential), and some had more than one elevator. Thus, it is reasonable to expect that elevator usage differs across buildings.

The ANOVA also showed a significant main effect of sign/baseline condition, $F(8,737) = 2.15$, $MS_e = 0.179$, $p < 0.05$. The specifics of this effect are described below.

The second stage of analysis focused on whether there were differences among the five baseline conditions (where proportion compliance ranged from 0.69 to 0.75). A chi-square analysis showed no significant effect, $\chi^2(4, N = 474) = 1.10$, $p > 0.05$. Thus, in order to simplify the remaining analyses, the five baseline conditions were collapsed to produce a single no-sign baseline condition.

The third and most important analysis specifically examined compliance to the four sign conditions as well as the collapsed baseline. Mean proportion compliance and ridership totals for these conditions are shown in *Table 2*. A chi-square analysis showed a significant effect of condition, $\chi^2(4, N = 791) = 14.29$, $p < 0.01$. Paired comparisons among the conditions showed that sign D (the enhanced sign) produced significantly higher compliance than the other three signs and baseline ($p < 0.05$). All other paired comparisons among conditions in *Table 2* were not significant.

Table 2 Proportion compliance (and total ridership, *N*) as a function of sign condition

Measure	Sign condition				
	No-sign Baseline	A Original	B Revised—long	C Revised—short	D Revised—enhanced
Proportion compliance	0.73	0.67	0.71	0.77	0.91
N	474*	79	82	86	70

Note: compliance to sign D is significantly greater than the other sign/baseline conditions
**N* for the baseline is across five periods of measurement

Discussion

Results indicate that only sign D, the enhanced sign with colour, signal word, icons, pictorial, and direct, explicit wording of the required behaviour and consequences increased behavioural compliance (the number of passengers not riding up one floor or down two floors) over the baseline control periods. This conclusion is based on two findings. First, fewer people disobeyed the enhanced sign D, and second, as is shown in *Table 2*, the total number of passengers decreased with sign D. This lower rate of ridership suggests that this sign reduced the number of people who would have used the elevator for travelling a short-distance but instead used the stairs. The second piece of evidence is not as strong as the first as actual stair use was not measured.

General discussion

The results support some of Chapanis' speculations regarding the elevator signs that he cited 30 years ago. The original sign (A) seen in the Baltimore hospital was perceived by participants in Experiment 1 to be low in understandability and they reported being less willing to comply with its directives than with any of the other signs. Moreover, it produced a level of compliance that was no different than when there was no sign posted. This confirms that the sign originally posted at the Baltimore hospital needed to be improved as Chapanis suggested.

Chapanis proposed two other signs which he believed might be better. The first and lengthier revision (sign B) produced significantly higher understandability and willingness to comply ratings than the original sign. The second and more concise revision (sign C) was also found to produce significantly higher ratings than the original sign.

The data also address Chapanis' uncertainty with regard to sign C's adequacy—specifically, whether the briefer sign C is as understandable as sign B. The data show that sign C was given significantly lower evaluations than sign B. Apparently sign C's brevity compromises its understandability by omitting material present in sign B concerning the consequences of compliance. Finally, Experiment 1, as expected, showed that the more recently-designed sign D, incorporating several enhancement features, was rated highest of all signs on both understandability and willingness to comply.

Experiment 2 took the testing one step further. The four signs were posted at elevators of various buildings and compliance behaviour was measured and compared among the sign conditions and to a series of base line no-sign periods. The results showed that

neither the original sign nor Chapanis' two revised signs produced compliance behaviour that was different from the no-sign periods. So while the subjective judgements of Experiment 1 showed significant differences in ratings among the three Chapanis signs, no such differences were found using the behavioural compliance measure in Experiment 2. This type of discrepancy is not unusual in warnings research. Rating studies frequently show a significant difference that is not found in compliance studies (and it is virtually never the other way around). There are at least three reasons that can be offered for the differences. First, rating studies tend to be more sensitive to subtle differences because there is greater statistical power from being composed of a continuous range of values (Experiment 1 employed a nine-point rating scale) as compared to compliance studies which involve yes–no dichotomous scores (as in Experiment 2). Second, the two experiments used different experimental designs: Experiment 1 was a repeated-measures design where participants saw all signs, whereas Experiment 2 was a between-subjects design where participants saw only one sign. Although care was taken to balance presentation order in Experiment 1, the analyses showed some evidence of carryover. The repeated-measures design allowed comparisons to be made between signs currently being rated and previously-viewed ones which in turn probably enhanced subtle distinctions between them in the rating evaluations. These distinctions are not knowable by participants in Experiment 2. Third, a whole host of other variables might have affected behavioural compliance outcomes that were not present in the ratings. These variables include people's physical and mental fatigue, whether a person is travelling with someone else, how rushed the person is, etc.

Despite the differences between the results of the two experiments for the three Chapanis signs, both the rating and the compliance measures were consistent in showing that the enhanced sign D with a signal word panel, icons and pictorials, and explicit wording of the required behaviour and consequences produced the best scores. This finding confirms research showing these features improve noticeability, comprehension and compliance in studies performed since the original Chapanis (1965) article.

Because there were several enhancements made to sign D, it is difficult to attribute particular reasons for its beneficial effect. Few studies (e.g. Wogalter *et al*, 1993) have examined combinations of features, most have examined individual features. However, in actual applications, one expects signs to be composed of combinations of features. Further research is needed on the benefits of multi-featured signs. In particular, rather than taking an additive focus like most studies which attach individual features to a base textual message, a subtractive focus might be useful. A subtractive focus would start with a realistic (from an applications standpoint) multi-featured sign and measure the relative effectiveness after removing or changing a feature, e.g. whether a smaller or a non-coloured sign D makes a difference. Also, additional research might further improve sign D by evaluating changes to the layout, wording and pictorials, and could examine placement, long-term effects and people's attitudes toward the sign, elevator and stairs.

A few comments should be made regarding the technique used to measure behavioural compliance. In Experiment 2, an observer rode the elevator during the time ridership was recorded. Previous warnings research has shown that the presence of another person could influence people's compliance behaviour (Wogalter *et al*, 1989). For example, some individuals who intended to take a short ride might be too embarrassed to get on after seeing one or more individuals in the elevator, or if they do get on, they might ride longer distances than intended to avoid the disdain of other riders. A better, more elaborate method might incorporate stationing video cameras unobtrusively on each floor to record observations.

Also in Experiment 2 only elevator ridership was measured. A stronger set of data would also include measurement of stair use. It would be expected that as the proportion of elevator riders going longer distances increased (as with the enhanced sign D), simultaneously a greater proportion of individuals should be using the stairs for shorter distances. Stair use was not assessed in the present study because of the considerable resources that it would require: (a) having a research assistant posted on every floor of the building, (b) a method of communicating between them and (c) extensive coordination efforts to determine which floor individuals entered and exited. Thus, while stair use data would be desirable, the difficulties associated with its collection probably precludes its measurement except in special circumstances. Other researchers might have access to locations where such data could more easily be collected such as buildings with existing video cameras posted in hallways, elevators and stairs with a centralized set of video display units to view people's behaviour. Even without the stair use data, we believe that the present data is a reasonably good indication that the enhanced sign was effective in changing people's use of the elevators. Moreover, the total number of people using the elevator in the enhanced sign condition was lower than any of the other sign conditions, suggesting that more people in that condition used the stairs.

In Experiment 2 no demographic data of participants was collected and therefore it can not be determined whether certain personal characteristics relate to elevator use with and without the signs. The main reason for not collecting these data was its potential intrusiveness. Having people answer questions while riding the elevator would most certainly affect their behaviour in this context. However, subsequent research might survey or interview individuals exiting the elevator (or stairs) to assess various personal as well as situational characteristics. For example, one might expect that elderly and perhaps overweight individuals use the elevator more frequently for both shorter and longer trips than younger and non-overweight individuals.

Additionally, no procedure was employed to track individuals on whether they used the elevator more than once during the recorded time intervals. While it is probably the case that some individuals were recorded more than once, given the relatively short time periods measured at separate buildings, the number of redundant counts is likely to be only a small proportion of the total ridership and likely to be

distributed nonsystematically across conditions. Also, short of asking people whether they rode the elevator in the last two hours or so, the determination of redundant individuals would be extremely challenging. The observer would have to record the appearance of riders (e.g. clothing, face characteristics, etc.) and then later try to decide whether individuals were previously on the elevator. Such data collection (like that of the demographics) was deemed too intrusive as it could influence the riders' behaviour.

Addressing elevator sign compliance may seem trivial, but the inconvenience generated by 'slow' elevators has costs—particularly for individuals who must traverse several floors to get to their destination. Not only do they have to wait for the elevator to arrive, but also must wait on intermediate floor stops—over the long haul, these waits can add up to considerable wasted time and productivity, as well as annoyance. In other settings, enhancements, such as those incorporated in sign D, could have greater importance, e.g. on health and safety warnings. Thus, the practical importance of sign studies, such as this, is frequently in its implications for other applications.

Acknowledgements

The authors would like to thank Eric Martin, Jay H. Williams and Stephanie A. Terry for their assistance in this research. Portions of this study were reported at poster sessions at the Human Factors and Ergonomics Society 38th Annual meeting (October 1994) in Nashville, TN, USA and at the Southeastern Psychological Association meeting (March 1995) in Savannah, GA, USA.

References

Chapanis, A. 1965 'Words, words, words...' *Hum Factors* **7**, 1–17

Cochran, W. G. 1950 'The comparison of percentages in matched samples' *Biometrika* **37**, 256–266

Friedmann, K. 1988 'The effect of adding symbols to written warning labels on user behavior and recall' *Hum Factors* **30**, 507–515

Laughery, K. R., Vaubel, K. P., Young, S. L., Brelsford, J. W. and Rowe, A. L. 1993 'Explicitness of consequence information in warnings' *Safety Science* **16**, 597–613

Laughery, K. R., Wogalter, M. S. and Young, S. L. (eds) 1994 *Human Factors Perspectives on Warnings: Selections from Human Factors and Ergonomics Society Annual Meetings*, 1980–1993 Human Factors and Ergonomics Society, Santa Monica, California

Wogalter, M. S., Allison, S. T. and McKenna, N. A. 1989 'The effects of cost and social influence on warning compliance' *Hum Factors* **31**, 133–140

Wogalter, M. S., Godfrey, S. S., Fontenelle, G. A., Desaulniers, D. R., Rothstein, P. and Laughery, K. R. 1987 'Effectiveness of warnings' *Hum Factors* **29**, 599–612

Wogalter, M. S., Kalsher, M. J. and Racicot, B. M. 1993 'Behavioral compliance with warnings: effects of voice, context, and location' *Safety Science* **16**, 637–654

Young, S. L. and Wogalter, M. S. 1990 'Comprehension and memory of instruction manual warnings: conspicuous print and pictorial signs' *Hum Factors* **32**, 637–649