Perceived hazard for images depicting before and during consequences with two kinds of prohibition symbols

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This research examined the connoted danger level for symbols varying on type of prohibition symbol and depictions showing before- or during-injury consequences. One prohibition symbol was a red circle with a diagonal slash intended to show that the depicted event within the circle should not be performed. A similar, but less commonly used, prohibition symbol is the red circle without the slash. In the present research, 96 participants evaluated a set of symbols on two risk perception scales. Eight of the symbols viewed were manipulated with respect to a base concept depicting before- or during-injury consequences and type of prohibition. The results showed the symbols depicting during-consequence (injury) events produced significantly higher ratings than images showing before-consequence events. Symbols with a circle-slash prohibition were rated higher than the circle-alone prohibition, but only for some of the images. Symbols with both the prohibition circle-slash and during-consequences image tended to produce the highest ratings. In general, scoring participants' written interpretation of the symbols was relatively high for the manipulated images and did not differ as a function of condition. Very few critical confusions were noted (less than 5%) indicating, for example, no apparent confusions of "double negatives" when combining the during-injury consequences and the circle-slash prohibition symbol. More people expressed a negative (don't, no, not, or do not) in the verbal responses for images with the circle-slash prohibition symbol than with the circle-alone prohibition. Results and implications are discussed.

INTRODUCTION

One approach to conveying safety information is through the use of pictorial symbols (Dewar, 1999; Wogalter, Silver, Leonard, & Zaikina, 2006). Warnings that include symbols are more likely to capture people's attention (Leonard, Otani, & Wogalter, 1999) and can enhance the comprehension of hazard information including actions that should or should not be taken and the consequences of hazardous contact (Wogalter & Leonard, 1999).

Safety symbols can depict various kinds of images. Frequently, images depict hazard concepts. Images can show events before *or* during hazardous contact. The during-hazard depictions illustrate the consequences of hazardous contact in a direct manner (e.g., fingers being crushed by gears). Before-hazard symbols depicted the situation before hazardous contact.

Prohibition has been symbolized in a number of ways. A common graphic for prohibition is the circle-slash. Another is simply a red circle which is also used to convey a restriction of some activity or event depicted within the circle. Previous research has indicated that the use of the circle-slash combination can sometimes decrease the legibility and comprehensibility of some symbols as the "over" slash can sometimes obscure critical components of the underlying depiction (Dewar, 1976; Murray, Magurno, Glover, & Wogalter, 1998). The red circle alone may be more ambiguous and less danger-connoting than the circle-slash if there is an expectation that strong prohibitions have a slash. This research seeks to determine whether the red circle with and without the slash is better or worse with respect to danger connotation.

Prohibitions can be combined with the before and during depictions. With a during-consequences image, a prohibition icon is not needed since it is already depicting a "negative," i.e., the consequent injury to be avoided. In other words, for during-consequence images a circle-slash prohibition may be extraneous since it is apparent from the depicted injury event what should *not* be done. While a prohibition symbol may not be

necessary, it might nevertheless be used with a during-consequences symbol to add even greater emphasis. In other words the combination may add strength, such as producing greater danger connotation. Alternatively, the combination could produce confusion if interpreted as a "double negative," or that two negatives equal a positive (Wogalter, Murray, Glover, & Shaver, 2002).

The present study measures people's danger perceptions as a function of two prohibition symbols with before- or during-consequence depictions.

METHOD

Participants

Data was collected from 96 student participants who were taking introductory psychology courses for research credit. Participants ranged in age from 18 to 41 years with a mean age of 19.7 years (*SD* = 2.92 years). The sample was composed of 60 males and 36 females. The ethnicity of the sample was: 71 Caucasian, 14 African-American, 5 Asian, and 6 multi-ethnic backgrounds. Ninety participants (94%) reported English as their primary language.

Materials and procedures

Stimuli were based on common public-domain symbols. Most were taken from computer clip art or scans of safety catalog images (e.g., Lab Safety Supply, 2002). Internal images of symbols were black and the circle-alone and circle-slash components were red. Symbols were presented to participants in 3-page booklets with 10 symbols per page printed on card stock. Participants completed all tasks in less than 30 minutes.

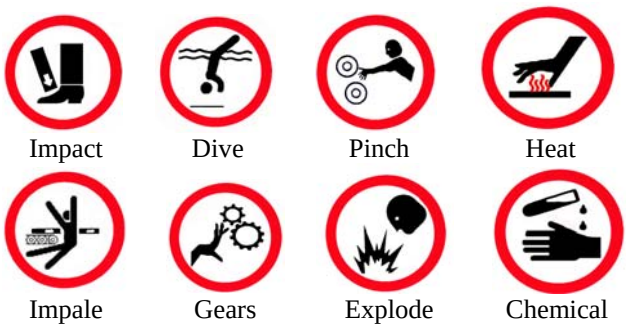

Figure 1. *Illustration of 8 base concepts depicted in the before-consequence and circle-alone condition.*

Each participant was shown a total of 30 randomly ordered symbols of which 22 were filler symbols to help disguise the nature of the manipulation. For each item, participants were asked to rate the level of danger associated with that particular symbol and the level of carefulness it suggested. The eight base concepts are illustrated in Figure 1 in the before-injury consequence conditions and with the circle-alone prohibition. The four manipulated conditions were:

(a) circle-alone image with before-consequence illustration,
(b) circle-alone image with during-consequence illustration,
(c) circle-slash image with before-consequence illustration,
(d) circle-slash image with during-consequence illustration.

Participants viewed only one image of each base concept in the set that they viewed. An example of the four 2 x 2 conditions for the gears' base concept is depicted in Figure 2.

Figure 2. *Example the gears concept as before- and during- consequences with circle-alone vs. circle-slash*

Participants were asked to rate symbols on two risk perception scales: (a) “How much danger does this symbol convey?” and (b) “How careful would you be upon seeing the symbol?” Both involved a 9-point Likert-type scale with the numerical and verbal anchors. The "dangerous" scale was: (0) not at all dangerous, (2) somewhat dangerous, (4) dangerous, (6) very dangerous, to (8) extremely dangerous. The carefulness scale was identical except the word careful was substituted for dangerous.

After all of the ratings were completed, participants were asked to give a written description of the meaning of each symbol that they saw. These responses were scored with respect to liberal comprehension accuracy (gist understanding). Also, errors of comprehension were examined for critical confusions (opposite answers or answers that could result in an injurious interpretation).

RESULTS

Preliminary analyses suggested that both ratings of danger and carefulness produced similar patterns of means as a function of conditions. The Pearson product moment correlation coefficient between the paired ratings of all participants was .84, N=1182, $p < .0001$.

To facilitate ease of exposition the two scores were collapsed by taking means of the two ratings to form a combined dependent measure, hereinafter called "Perceived Hazard." This is a reasonable name for this new variable because previous research has noted a high positive correlation between hazard perception and intended carefulness (e.g., Wogalter, Brelsford, Desaulniers, & Laughery, 1991).

Perceived hazard

A 2 (prohibition symbol: circle-alone vs. circle-slash) x 2 (before- vs. during-consequences) x 8 (base concept) mixed-model analysis of variance (ANOVA) was employed using the combined score described above. The ANOVA showed significant main effects for before- and during-consequences, $F(1, 92) = 7.34$, $p < .01$, and base concept, $F(7, 644) = 23.71$, $p < .00001$. The during-consequences images ($M = 5.32$) were given higher hazard ratings than the before-consequences images ($M = 4.64$). The means for base concepts are shown in the right-most column of Table 1. Tukey's Honestly Significant Difference (HSD) test (at $p = .05$) showed that Chemical, Explode, Gears, and Impale (which did not differ from one another) were all rated significantly higher than the other base images, except for Impale which did not differ from Heat. Heat, Pinch and Dive did not differ among themselves but they were all significantly higher than Impact, which was the lowest.

Table 1
Mean Perceived Hazard (composite score) as a function of prohibition symbol: circle-alone vs. circle-slash) and base concept

Base concept	Circle-alone	Circle-slash	*Mean*
Chemical	5.72	5.59	5.66
Explode	5.92	5.32	5.62
Gears	5.39	5.50	5.44
Impale	5.60	5.17	5.39
Heat	4.60	5.04	4.82
Pinch	4.60	4.96	4.78
Dive	4.25	4.94	4.59
Impact	3.42	3.67	3.54
Mean	4.94	5.02	

There was no significant main effect of prohibition symbol (circle-alone vs. circle-slash), nor did it yield a significant interaction with the before- versus during-consequences factor, both Fs < 1.0. However, a planned comparison between before- and during-consequences for images having the circle-slash prohibition was significant, $F(1, 92) = 5.26$, $p < .05$, yet the same comparison for the circle-alone prohibition was not, $F(1, 92) = 2.37$, $p > .10$.

The ANOVA also showed a significant interaction of prohibition symbol and base concept, $F(7, 644) = 2.30$, $p < .05$. The means are shown in Table 1. Simple effects analyses failed to find any significant comparisons between any of the base concepts as a function of circle-slash vs. circle-alone prohibition. Thus, the interaction of prohibition and base concept was probably produced by small reversals in the pattern of means.

Lastly, the ANOVA also showed a significant interaction of before- vs. during- consequences and base concept, $F(7, 644) = 4.75$, $p < .00001$. These means are shown in Table 2. Simple effects analysis comparing before- vs. during-consequences for each of the base concepts showed significantly higher during-consequence means for the Impale, Gears and Pinch base symbols. The three factor interaction was not significant, $F(7, 644) = 1.53$, $p > .10$.

Table 2
Mean Perceived Hazard (composite score) as a function of before- and during-consequences and base concept

Base Concept	Before	During	*Mean*
Chemical	5.33	5.98	5.66
Explode	5.66	5.58	5.62
Gears	4.97	5.92	5.44
Impale	4.78	5.99	5.39
Heat	4.73	4.92	4.82
Pinch	3.85	5.71	4.78
Dive	4.48	4.71	4.59
Impact	3.34	3.74	3.54
Mean	4.64	5.32	

Comprehension test

Written responses were scored as 1 = correct and 0 = incorrect using a lenient criterion that accepted gist answers as correct (as opposed to strict or exactly-worded definitions). Example responses in the written comprehension test are shown in Figure 3.

- Do not put hands near gears
- Keep away hands
- Do not stick your hands in here

- Keep hands away from gears
- Hands may get caught in machinery
- Watch for moving gears

- No diving – shallow water
- Do not dive too strongly because you might hit your head into bottom
- No diving

- No diving
- Danger shallow water
- No diving in shallow water

Figure 3. *Examples of participants' answers on the symbols meaning task.*

The ANOVA for the comprehension scores were analyzed in the same way as the perceived hazard scores. The ANOVA showed no main effect or interaction of the two main manipulated IVs (prohibition symbol and before- vs. during-consequences). However there was a significant main effect of base concept and it interacted separately with each of the other IVs. Table 3 shows proportion correct as a function of before- and during-consequences and base concept.

The main effect means of base concept are shown in the right-most column of Table 3, $F(7, 644) = 10.96$, $p < .0001$. Comparisons among the means using Tukey's HSD test indicated that the Impale concept was significantly lower than all symbols except for Impact and Explode. The two highest, Chemical and Heat, were significantly higher than the remaining concepts except for Gears and Dive. No other differences were significant.

The before- vs. during-consequences by base concept interaction, $F(7, 644) = 4.02$, $p < .001$, yielded only two significant comparisons: for Pinch and Explode, with during-consequences higher for the former and before-consequences higher for the latter. These means can be seen in Table 3.

Table 3
Proportion correct as a function of before- and during-consequences and base concept

Base Concept	Before	During	*Mean*
Chemical	1.00	.98	.99
Explode	.92	.71	.81
Gears	.92	.94	.93
Impale	.63	.75	.69
Heat	.98	.98	.98
Pinch	.73	.94	.83
Dive	.88	.94	.91
Impact	.75	.85	.80

The prohibition by base concept interaction, $F(7, 644) = 3.76$, $p < .001$, yielded only one significant comparison. The Impale symbol inside a circle-alone prohibition ($M = .83$) had higher comprehension scores than within the circle-slash prohibition ($M = .54$)

Critical confusion errors were very low. None of the base concepts yielded more than 5% critical confusions. This low occurrence of critical confusion errors suggests that people were relatively adept at assigning the correct meaning to these symbols yet some symbols appeared to pose more of a problem than others as illustrated by the differences in proportion correct scores among the base concepts in Table 3. For instance, the Chemical ($M = .99$) and Heat ($M = .98$) symbols were almost universally recognized whereas the Impact ($M = .80$) and Impale ($M = .69$) symbols were less likely to be recognized. Anecdotally, the independent coders of the comprehension data provided suggestions to illustrate why the Impact symbol tended to be less recognizable. Most of the internal image of this symbol was a boot. It is intended to communicate the need for protective footwear (e.g., steel-toed boots), but the meaning does not appear to be as readily apparent as some of the other symbols. Although it also shows a falling object, it is less apparent than the boot and the specific protective attributes of the footwear are not successfully illustrated. The meaning of this symbol may require more inference than some of the others.

To further illustrate the qualitative differences in responding by participants, the verbiage of written responses to each symbol were also examined for

content (i.e., the use of the words "don't," "no," "not," and "do not" were tallied). Overall, these words were much more frequently given with the circle-slash prohibitions (57% for the before-consequence image and 40% for the during-consequence image) than the circle-alone conditions (14% for both before- and during-consequence images).

DISCUSSION

Symbols were examined under experimentally manipulated conditions: images showing before- or during-injury consequences combined with the prohibitions of circle-slash and circle-alone. A number of findings emerged. First, images that depict the during-injury consequences were rated more hazardous than those that depict before-injury conditions. This may be due to some aspects of injury not being as apparent in the before-consequences than in the during-consequences images.

Second, some base concepts convey different levels of hazards than others. This would be expected because the base concepts varied in depicted hazard. Chemical hazards and explosions were considered more hazardous than an injury to the foot.

Third, although not statistically significant, the circle-slash prohibitive design appeared to have been more effective than the circle-alone prohibitive symbol at influencing participants' perceived hazard. The circle-slash prohibition was found to be different from the circle-alone prohibition in a planned comparison. For the circle-slash prohibition, the during-consequence images received higher hazard ratings than the before-consequence images, but this before- vs. during-difference was not found for the circle-alone prohibition symbol. Furthermore, while the comprehension results showed mostly correct understanding of the symbols, they also illustrated less equivocal and more prohibitive language (e.g., "don't") for images having the circle-slash than the circle-alone prohibitions. Most of base concepts exceeded the criterion of 85% correct. Of the remaining that did not, most just fell below the 85% criterion. The only base concept that seemed inadequate was Impale. Impale suffers most when there was a circle-slash prohibition where the slash covers some of the detail of the image. The problem of obscuration of detail of the "over" slash as been noted in previous research (Dewar, 1976, Murray et al., 1998; Wogalter et al., 2002).

There are a number of safety symbol design implications that can be derived from the present results. The use of the during-consequence (injury) images tended to result in higher ratings than before-injury consequences. While the findings between the two prohibition conditions are not large with respect to perceived hazard or comprehension, the results suggest that combining the circle-slash with the during-consequences produces a modest improvement. Also, the circle-slash prohibition tends to generate more responses of "no" and "don't."

One issue mentioned earlier concerned the possibility of producing "double negative" confusions, particularly with respect to the circle-slash and the during-consequence combination. No discernable confusions were found, however. If the during-consequence image in combination with the circle-slash were confused as a "double negative" effects would be seen in the ratings and critical confusion errors, and this was not noted in the data. Indeed, the combination tended to produce the highest ratings.

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