Habituation, Dishabituation, and Recovery Effects in Visual Warnings

Soyun Kim and Michael S. Wogalter
North Carolina State University, Psychology Department
Raleigh, North Carolina 27695-7650 USA

Decrement of visual attention to repeatedly exposed warning labels and signs has been discussed in the warning literature without much empirical research support. The present research examined whether habituation, dishabituation, and recovery of habituation occur to visually presented warnings. Participants (N=72) were presented to a long sequence of repeated visual warnings (40 warnings presented 8 times = 320 initial trials) in a particular format (ANSI or OSHA type formats), followed by 5 warnings manipulated either in the same or different format. Five more warnings in same format as in the initial trials were presented to end the sequence. Measured were participants' ratings of perceived alertness to each warning. Findings showed a decrease in ratings from beginning to end of the initial 320 trials, indicative of habituation. Dishabituation was observed with higher ratings when the warning format changed. Evidence of habituation recovery of lowered ratings was observed upon return to the previously habituated (initial trials) format after a set of different formatted warnings. Implications for formalized standards and guidelines, which recommend an unchanging, relatively constant format, are discussed.

INTRODUCTION

Since the mid 1980s there has been a large body of research on warnings that examines factors that influence warning effectiveness (Laughery, 2006). However, there has been very little research examining the issue of habituation with respect to warnings, although it has been discussed in numerous articles (Wogalter & Silver, 1995; Edworthy & Adams, 1996). Habituation is defined as reduced attentional response to repeated exposure to a stimulus. Habituation has been found in a variety contexts and domains (e.g., in animal learning and infant studies; Thompson & Glanzman, 1976; Cohen, 1976). In the context of warnings, Wogalter and Vigilante (2006) described that a salient stimulus initially may attract attention, and while attention is maintained on the stimulus encoded, memory is formed which in turn causes the stimulus to become less salient. Thus, as a consequence of memory formation, attention to the stimulus is reduced; it is less salient (Wogalter et al., 2006). Memory formation is generally considered beneficial. However, habituation is problematic with respect to warnings for at least three reasons. One is that the warning loses its alerting capability. This is a problem if the consequence is people getting hurt because the warning is no longer alerting. A second problem is that people may prematurely decrease or stop attending to a warning before he or she acquires all of the information from the warning into memory. A third potential problem is that after habituation, another warning similar in appearance may elicit less response than it should (Wogalter & Vigilante, 2006).

Despite its mention in the warning literature, empirical research on warning habituation is rather limited. One study was reported by Thorley, Hellier, and Edworthy (2001). They manipulated levels of hazard by varying the color and signal words. As a measure of compliance of the warning, they observed door use behavior over a period of eight sessions. They found that compliance behavior decreased as function of time following repeated exposure to a visual warning, indicating the occurrence of habituation. However, the manipulation to show a dishabituation showed unclear results. In another study, Thorley, Hellier, Edworthy, and Stephenson (2002) used skin conductance as the measured response to repeated exposures to either text-based warning or picture-based visual warning signs over 12 trials. A significant decline in skin conductance response across the trials was shown, indicating the occurrence of habituation. Like the earlier study, they also attempted to demonstrate a dishabituation effect by an increased skin conductance response when a novel stimulus was presented subsequent to the sequence. However, the results they found only partially supported a dishabituation effect. Dishabituation was clearer for text-based warnings than for picture-based warnings.

The present research examined the question whether habituation occurs with visual warnings in a different manner than used in the previous research. The present research used a more substantial repeated visual warning exposure procedure (over 300 trials) than was employed in the two earlier studies. The initial warning-presentation sequence was followed by five test slides. Some of the test slides were in the same formatting as the initial trials and

some were in different formatting from the initial trials. This was to determine evidence of a dishabituation effect.

Also examined was another aspect of habituation that heretofore has not been investigated in warning research, namely recovery of habituation. However, this effect has been found in experimental studies in other contexts (e.g., in infant studies, Pancratz & Cohen, 1970). The present study examined whether the habituated response of reduced ratings would return upon re-presentation of warnings that were previously habituated (from the initial trials).

In the present study, participants were exposed to a long series of warnings and rated each of them on perceived alertness. Examined was whether alertness ratings decrease over a long sequence of repeated exposure to warnings in a particular format. Also examined was whether changing the warning format has a dishabituation effect of increasing the alertness ratings. Lastly, when changing back to the original format, it was asked whether the habituated response would recover and again return to lower ratings of perceived alertness.

METHOD

Participants

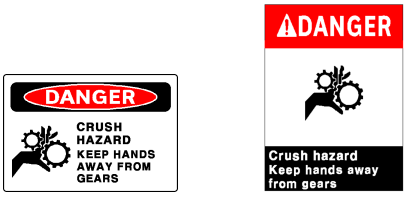
A total of 72 individual (44 males, 28 females) participated from a pool of potential research participants at North Carolina State University in Raleigh, North Carolina. Average age was 19.0 (SD=3.12). Although participants were recruited from a pool of persons taking a psychology introductory course, their major areas of study were in a variety of disciplines.

Materials and Stimuli

Two distinctive formats of warnings were produced for use as stimuli. One version was based on the original Occupational Safety and Health Administration (OSHA, 1972); it is the old ANSI-Z535.2 (1991) standard. The actual size of the stimuli was 5 x 7 inches (12.50 x 17.8 cm). They were in landscape orientation (long side is horizontal) and contained a symbol (pictorial) on the left side and warning text in black font, all caps on white background centered on the right side. They had a signal word 'DANGER' heading text in white font on red background was surrounded by black rectangular background. An example is shown in Figure 1-a.

The other version was based on the format in the American National Standards Institute's (ANSI) Z535.4 (1991, 2002) warning standard for product safety labels and also the current sign format ANSI Z535.2 (2002). They were a portrait orientation (long side is vertical) and were approximately the same size, 7.5 x 5.7 inches (19 x 14.5 cm) as the other format. An example is shown in Figure 1-b. These warnings had a symbol (pictorial) in the center area and a hazard description in white font at black background at the bottom aligned to the left side of the label. They had a signal word 'DANGER' heading text in white font on red background and a red exclamation mark on white background. All warning text was printed in Helvetica (san serif) font. Forty warning labels at each version were created for various formats of hazards (e.g., chemical hazard, electrical hazard, etc).

Both formats had exactly the same content (i.e., matched). Thus, other than format (appearance) the basic content of the two formats were the same in terms of signal words, hazard information, instructions as to how to avoid the hazard, and pictorials. The labels were produced with label creator software, Bar Code Labeler v4, Bear Rock Technologies Corp. and edited with the Adobe Photoshop 7.0. The stimuli were presented on the computer screen as a Microsoft PowerPoint slide show.



(a) OSHA format (b) ANSI format

Figure 1. Visual warning signs

The stimulus presentation sequence consisted of three parts: initial, test, and post-test. In the initial trials, 40 warnings were presented 8 times for a total of 320 presentations. As part of the continuous sequence, the initial trials were followed by 5 warnings selected from the original 40 as the Test trials. For half the participants, the test trials warnings were in the same format as seen in the initial trials. For the other half, the test trials warnings were presented in a different warning format from the initial trials. As a last part of the sequence, the test trials were followed by 5 additional warnings (selected from out of the original 35, excluding the 5 warnings to avoid reshowing the test trial warnings) as the post-test trials. These trials were used to examine whether a recovery from habituation would be shown.

A total of four conditions were formed by manipulating two between-subjects factors as shown in Table 1. Conditions involved 320 initial trials, 5 test trials, and lastly 5 post-test trials. In the same format conditions, all of the warnings were in the same format (O-O-O, A-A-A). Different format conditions involved switching to another format in the Test Trials (either O-A-O or A-O-A). The post-test trials always had warnings in the same format as the initial slides.

Table 1. *Summary of Four Conditions by Trials, Same vs. Different, and Format (O=OSHA, A=ANSI)*

Conditions	Trials		
	Initial (1-320)	Test (321-325)	Post Test (326-330)
Same format			
O-O-O	OSHA	OSHA	OSHA
A-A-A	ANSI	ANSI	ANSI
Different format			
O-A-O	OSHA	ANSI	OSHA
A-O-A	ANSI	OSHA	ANSI

Procedure

Upon arrival, participants were asked to read and sign an informed consent form and complete a demographic questionnaire. After signing informed consent form and demographic information, participants were given answer sheets and a set of instructions. An experimenter read the instructions aloud to participants. Participants were told to look at an asterisk at the center of the screen before the sequence began. Participants were asked to look at carefully each warning image at least 4-5 seconds and to rate each according to the following question: "How strongly do you feel you were alerted by this label?" using a Likert-scale from 1 to 7, with 1 "Not at all alerted," 4 "Alerted," and 7 "Extremely alerted." Each participant was escorted individually to a desk with a computer and was requested to sit comfortably in front of the monitor at an approximate 17.7 inches (45 cm) distance. A Dell Latitude laptop computer with 14.1inch (35.8cm) display was used. Up to six participants at one time took part in the study. Participants were randomly assigned to one of 4 between subjects conditions.

Warning presentation trials were paced by a beep sound given at a 7 second rate. The pacing helped the participants to complete their ratings before the next warning was presented. Two orders of stimuli in sequences were used. One was a randomized order determined by a random number generator program and the other was the reversed order. After completing all tasks, participants were debriefed and thanked for their time.

RESULTS

Compiling scores

Four participants were excluded from analyses; three provided incomplete ratings, and one gave the same rating for every warning yielding no variance (SD=0).

Only four portions of the data were selected for analysis from the entire set of trials. The selected trials are as shown in Table 2. The first 40 ratings in the initial trials (Trials 1-40) were termed as the Initial Trials 1, and the last 40 ratings in the initial trials (Trials 281-320) were termed as the Initial Trials 2. Test Trials were the 5 warnings in Trials 321-325 and Post-Test Trials were the 5 warnings in Trials 326-330. For analysis, scores were means compiled from the ratings given the four sets of trials (Initial Trials 1, Initial Trials 2, Test Trials, and Post-Test Trials). Thus, each participant had 4 rating means from participants' sets of trials that entered into the data analysis.

Table 2. *Summary of the selected ratings out of entire set of trials for analysis*

Trials			
1-40	281-320	321-325	326-330
Subset of Initial Trials 1	Subset of Initial Trials 2	Test Trials	Post-Test Trials

Pattern of means

The overall means as a function of warning format and trials are shown Figure 2. This figure reveals several interesting patterns. Examination of the Initial Trials 1 and Initial Trials 2 means shows that repeated stimuli exposure decreased the alertness ratings from beginning to end. This decline is an indication of habituation. When comparing the Initial Trials 2 and Test Trials, only the two Different conditions (O-A-O, A-O-A) show an increase in ratings at the Test Trials, indicating dishabituation. In addition, between the Test Trials and Post-Test Trials, ratings decreased in the two different conditions (O-A-O, A-O-A), indicating recovery of habituation. Generally, the OSHA warning format showed somewhat higher alertness ratings than the ANSI warning format.

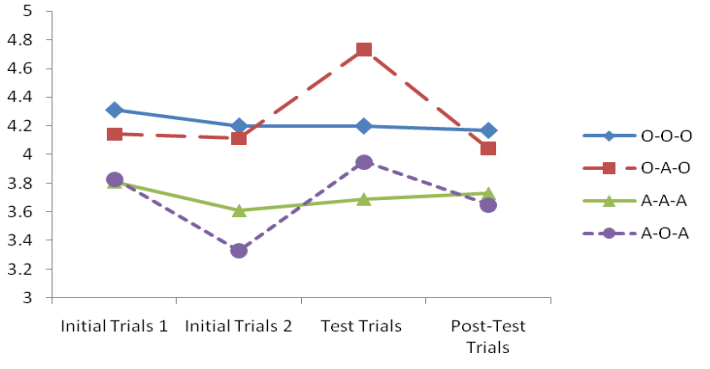


Figure 2. Comparison as a function of warnig format and trials

Analysis

Specifically, to examine habituation effect, the difference between Initial Trials 1 and Initial Trials 2 was compared. A 2 (warning format: ANSI and OSHA) X 2 (trials: Initial Trial 1 and Initial Trial 2) mixed model ANOVA was conducted (warning format as the between-subjects factor and trials as the within subjects factor). The ANOVA showed that there was a significant main effect of Trials, F (1, 66) = 5.89, MSE=.261, $p < .05$. The means

and standard deviations in these conditions are shown in Table 3. The ratings Initial Trials 1 produced higher alertness (M=4.02) than Initial Trials 2 (M=3.81). There was also a significant main effect of Format, F (1, 66) =5.75, MSE=1.76, $p < .05$. The OSHA format produced higher alertness ratings (M=4.19) than ANSI format (M=3.64). There was no interaction. Table 3 shows means and standard deviations (SD).

Table 3. *Means (SDs) as function of trials and warning format*

Conditions	Initial Trials 1	Initial Trials 2
OSHA	4.28 (.86)	4.15 (1.19)
ANSI	3.82 (.87)	3.47 (1.04)

To examine whether there is a dishabituation effect when the warning format is changed, Initial Trials 2 and Test Trials were compared as a function of warning format. A 2 (warning format: ANSI and OSHA) X 2 (same versus different format) X 2 (trials: initial trials 2 and test trials) mixed model ANOVA was conducted (warning format and same vs. different as the between-subjects factors and trials as the within subjects factor). These means and standard deviations are shown in Table 4. The ANOVA showed that there was a significant main effect of Trials, F (1, 64) = 10.60, MSE=.352, p <.05. The Test Trials (M=4.17) had higher alertness than Initial Trials 2 (M=3.84). There was a significant main effect of warning format, F (1, 64) = 5.79, MSE=2.56, $p < .05$. OSHA warning format (M=4.31) produced higher alertness ratings than ANSI warning format (M=3.65). There was no main effect of same versus different format. However, the ANOVA also showed a significant interaction of trials and the same vs. different factors, F (1, 64) = 8.12, MSE=.352, $p < .05$. Means and standard deviations for conditions are shown in Table 5. Tukey's Honestly Significant Difference (HSD) test set at $p = .05$ indicated that the different test trials were significantly higher than the other means. Ratings increased from Initial Trials 2 to the Test Trials in the different format but not with the same format condition.

Table 4. *Means (SD) as function of trials, format and same vs. different*

Conditions	Initial Trials 2	Test Trials
Same		
O-O-O	4.20 (1.18)	4.20 (1.43)
A-A-A	3.61 (1.05)	3.69 (1.28)
Different		
O-A-O	4.11 (1.24)	4.73 (1.22)
A-O-A	3.33 (1.05)	3.95 (1.10)

Table 5. *Means (SD) as function of trials and same vs. different*

Conditions	Initial Trials 2	Test Trials
Same	3.94 (1.15)	3.98 (1.37)
Different	3.74 (1.20)	4.36 (1.22)

Lastly, to examine whether there is a recovery effect, test trials and post test trials were compared. A 2 (warning format: ANSI and OSHA) X 2 (same vs. different) X 2 (trials: test trials and post-test trials) was conducted. The means and standard deviations for these conditions are shown in Table 6. The mixed model ANOVA showed that there was a significant main effect of Trials, F (1, 64) = 4.07, MSE=.497, $p < .05$. Test trials, in general, had higher alertness ratings (M=4.17) than Post-Test trials (M=3.92). There were no main effects of warning format and same vs. different factors.

Table 6. *Means (SDs) as function of trials, format and same vs. different*

Conditions	Test Trials	Post-Test Trials
Same		
O-O-O	4.20 (1.43)	4.16 (1.16)
A-A-A	3.69 (1.28)	3.73 (1.16)
Different		
O-A-O	4.73 (1.22)	4.04 (1.33)
A-O-A	3.95 (1.10)	3.65 (1.35)

However, the ANOVA also showed a significant interaction of trials by same vs. different, F (1, 64) = 4.21, MSE=.497, $p < .05$. Means and standard deviations for conditions are shown in Table 7. Tukey's Honestly Significant Difference (HSD) test set at $p = .05$ indicated that the cell mean for Test trial in a different format was significantly higher than the other 3cell means. Alertness ratings decreased from Test trials to Post-Test trials in the different condition but not in the same condition.

Table 7. *Means (SD) as function of trials and same vs. different*

Conditions	Test Trials	Post-Test Trials
Same	3.98 (1.37)	3.98 (1.17)
Different	4.36 (1.22)	3.92 (1.25)

DISCUSSION

The results of the present study showed that there was a significant decrease in perceived alertness to the repeated stimuli exposure (i.e., from Initial trials 1 to Initial trials 2). The notion of repeated exposure of visual warnings producing a habituation effect was supported. A dishabituation effect was also evident between Initial Trials 2 and Test Trials due to the higher ratings after the

format was changed. Lastly, a recovery of habituation effect was shown by a drop in ratings in the different format condition when shown again warnings in its originally habituated format.

The results are consistent with the habituation findings of previous studies that employed skin conductance or behavioral compliance (see Thorley et al., 2001; Thorley et al., 2003). Thus, habituation effect is a robust phenomenon in that it occurs in studies involving different contexts and response measures. The present research is the first investigation in the warning literature to show a conclusive dishabituation effect. Previous research had been somewhat unclear on this issue. It also is the first warning study to show a 'recovery' effect after dishabituation. This was a return to low alertness ratings when warning in the habituated warning format were presented again.

The results showed that the OSHA warning format had higher alertness ratings than ANSI warning format. It is difficult to give a specific explanation for this effect except there had been a similar small effect reported in an earlier study (e. g., Wogalter, Kalsher, Frederick, Magurno & Brewster, 1998). Possibly the graphical elements of the oval shape in the OSHA warnings were considered more salient than the panel with the alert symbol (triangle - exclamation point) in the ANSI format. The OSHA version is an older format that is being phased out by the ANSI standard and it is possible that it has been seen in real world less often by younger adult college population. Note that not all forms of OSHA and ANSI warning formats were presented or tested in this study. Signs with the terms WARNING and CAUTION were not included. Additional future research is needed to give more definite explanation regarding the OSHA and ANSI difference found in this study.

The results in the present study have implication for standards guiding warning design. Standards and guidelines (e.g., ANSI Z535) tend to hold a particular format relatively constant. A positive aspect of standardization is that people may eventually learn what warnings look like. In this sense, a standardized warning appearing within a lot of visual clutter may be conspicuous because people will be better able to find a warning in the midst of visual noise (Wogalter & Leonard, 1999). However, when the same format of warnings is repeatedly exposed over time, standardization of format could lead to habituation and may decrease its ability to draw attention at potentially critical times. Some solutions to avoid or reduce the negative effects of habituation have been suggested. Four are discussed here. First, incorporating features that enhance conspicuity such as size and color could help to slow down or retard the habituation process (Wogalter and Vigilante, 2006). Second is stimulus change. Modifying or changing the warning's appearance every so often could be beneficial in reducing habituation. Third, there probably ought to be flexibility to allow a warning designer to deviate somewhat from the standards (Wogalter et al., 1999). Fourth, dynamic (changeable) warnings reduce or slow down habituation compared to state warning (Wogalter & Mayhorn, 2006; Wogalter et al., 2006).

REFERENCES

American National Standards Institute (ANSI) (1991). *Environmental and facility safety signs*. *Z535.2.*Washington, DC: National Electrical Manufacturers Association.

American National Standards Institute (ANSI) (2002). *Environmental and facility safety signs*. *Z535.2.* Rosslyn, VA: National Electrical Manufacturers Association.

American National Standards Institute (ANSI) (2002). *Product Safety Signs and Labels*. *Z535.4.* Rosslyn, VA: National Electrical Manufacturers Association.

Occupational Safety and Health Administration (OSHA, 1972). Hazard communication standard, 29 CFR 1910.

Pancratz, C. N., & Cohen, L. B. (1970). Recovery of habituation in infants. *Journal of Experimental child psychology*, 9, 2, 208-216.

Cohen, L. B. (1976). Habituation of infant visual attention. In T. J. Tighe & R. N. Leaton (Eds.), *Habituation* (pp. 49-93). New York: Lawrence Erlbaum Associates, Inc.

Edworthy, J., & Adams, A. (1996). *Warning design: A research prospective.* London: Taylor and Francis.

Thompson, R. F. & Glanzman, D. L. (1976). Neural and behavioral mechanisms of habituation and sensitization. In T. J. Tighe & R. N. Leaton (Eds.), *Habituation* (pp. 49-93). New York: Lawrence Erlbaum Associates, Inc.

Thorley, P., Hellier, E., & Edworthy, J., (2001). Habituation effects in visual warnings. In M. A. Hanson (Ed.), *Contemporary Ergonomics 2001* (pp.223-228). London: Taylor & Francis.

Thorley, P., Hellier, E., Edworthy, J. & Stephenson, D. (2002). Orienting response reinstatement in text and pictorial warnings. *Contemporary Ergonomics*. 447-451.

Laughery, K. R. (2006). Safety communications: warnings. *Applied ergonomics*, 37, 467-478.

Wogalter, M. S., Kalsher, M. J., Frederick, L. J., Magurno, A. B., & Brewster, B. M. (1998). Hazard level perceptions of warning components and configurations. *International Journal of Cognitive Ergonomics*, 2, 123-143.

Wogalter, M. S., & Leonard, D. S. (1999). Attention capture and maintenance. In M. S. Wogalter, D. M. Dejoy, & K. R. Laughery (Eds.), Warnings and risk communication (pp. 123-148). Mahwah, NJ: Lawrence Erlbaum Associates.

Wogalter, M. S., & Mayhorn, C. B. (2006). The future of risk communication: Technology-based warning systems. (Chap. 63) In M. S. Wogalter (Ed.) *Handbook of Warnings* (pp. pp. 783-793).Mahwah, NJ: Lawrence Erlbaum Associates.

Wogalter, M. S., & Silver, N. C. (1995). Warning signal words: connoted strength and understandability by children, elders, and non-native English speakers. *Ergonomics,* 38 (11), 2188-2206.

Wogalter, M. S., & Vigilante, W. J. (2006). Attention switch and maintenance. (Chap. 18) In M. S. Wogalter (Ed.) *Handbook of Warnings* (pp. 245-265). Mahwah, NJ: Lawrence Erlbaum Associates.