

Evaluation of Pictorial Symbols to Warn Computer Keyboard Users about Carpal Tunnel Syndrome (CTS)

Kenya Freeman

Michael S. Wogalter

*Department of Psychology
North Carolina State University
Raleigh, NC 27695-7801 USA*

ABSTRACT

Carpal tunnel syndrome (CTS) is an upper-extremity disorder that can cause chronic pain and disability. Although CTS can arise from a wide variety of repetitive tasks with awkward hand/arm positioning, a large percentage of cases are attributed to, or exacerbated by, computer input devices such as keyboards. One potential way to reduce the development of CTS in keyboard users is to warn them about the disease's early symptoms so that corrective actions might be taken before the disease becomes more severe. The present research systematically examines one of the components of a potential CTS warning, pictorial symbols. Participants examined a set of 12 ANSI Z535 style warnings with one, two or four pictorials. They then evaluated them on their perceived effectiveness, specifically on their ability to inform and motivate users to use correct arm and hand posture to avoid further CTS development. The evaluations involved estimating the percentage of people that would comply with the pictorial message if it were located on or near a keyboard. Individual pictorial symbols in a top or a side view of the hands, arms, and wrists, depicted the incorrect posture overlaid with either an "X" (cross-out) or "prohibition symbol" (circle-slash) or the correct posture with no overlay. Warnings with four pictorials (with both postures and views) were given significantly higher evaluations than warnings with one or two symbols. In the one and two pictorial conditions, the top view was preferred over the side view. The two prohibition symbols, shown together with views of the incorrect postures, were perceived to be better than the views of correct postures (with no prohibition symbol). The two prohibition symbol conditions did not differ. The results could serve as a partial basis for the development of a complete CTS warning that also includes textual information. Implications for the benefits of multi-symbol warning messages are offered.

INTRODUCTION

Kinzie (2001) suggests that an estimated one-third of all workplace injuries are repetitive-stress injuries. One kind of repetitive stress injury is Carpal Tunnel Syndrome (CTS), an upper-extremity disorder that can cause chronic pain and disability. In the 1990s, there were more than half million new CTS cases reported to physicians each year in the U.S. (Fried, 1998.) CTS can arise from a wide variety of repetitive tasks involving hands and arms in awkward positions. A large percentage of cases are attributed to, or exacerbated by, computer input devices such as keyboards (Utnage, 1995.) Because CTS can be debilitating, effective methods to inform people about proper keyboard use may ultimately help to reduce the number of repetitive motion injuries.

One potentially effective method of prevention is to use warnings to inhibit or reduce CTS. In a variety of domains, warnings have been found to capture attention, inform, and facilitate behavioral actions to avoid harm (e.g., Edworthy & Adams, 1996; Laughery, Wogalter & Young, 1994; Wogalter, DeJoy, & Laughery, 1999; Wogalter, Young, & Laughery, 2001).

Several design criteria have been proposed for warnings (e.g., Wogalter et al., 1987). A warning should be attention getting and stand out from a noisy background (i.e., it should be conspicuous.) A warning should be understandable to the population that is exposed to the hazard. It should also be concise and durable.

According to the American National Standard Institute's (ANSI) Z535 (1998) warning design standard, pictorial symbols are an optional component of safety signs. Pictorials may be used to clarify or supplement a portion of the textual message. Young and Wogalter (1990)

found that the presence of pictorials increases the likelihood that individuals will see a warning and remember it. Sojourner and Wogalter (1997) found that pictorial symbols are sometimes useful in conjunction with textual warnings and instructions.

The purpose of the present study was to examine whether having more symbols present was better than fewer symbols in communicating the importance of using the correct posture when typing. Kalsher, Brantley, Wogalter, and Snow-Wolff (2000) suggested multiple panel pictorials have the capacity to include more contextual details and potentially more risk information than individual symbols. Thus, the display of both the incorrect posture and the correct posture may be better than showing just one postural view. Likewise, presenting the top and side view may be more informative than presenting hand, arm, and wrist postures from only one perspective. In the present study, the potential effects of postural and perspective view were examined.

There has been limited research on whether safety symbols should depict a positive (safe behavior) or a negative (behavior to avoid) message. A study by Braun and Shaver (1999) suggest that participants consider highly negative symbolic depictions to be less effective than moderately negative depictions in safety symbols. Dewar (1976) and Murray, Magurno, Glover, & Wogalter (1998) showed differences in the legibility and comprehensibility of symbols using variations of the circle-slash prohibition symbol that is now commonly used in negation safety symbols (ANSI Z535, 1998) and (ISO 3864, 1984). Interestingly, while an "X", or cross-out symbol is sometimes used in warnings (e.g., Loring & Wicklund, 1988) and commonly in other domains as a negation symbol, comparison of the "X" and its preference over the circle-slash has not, to our knowledge, been conducted in experimental research. This comparison was another purpose of the present research.

The present study evaluated the perceived effectiveness of potential pictorial symbols for a CTS warning. Twelve warnings having ANSI-style characteristics were shown to participants with either one, two, or four pictorials in top and side views of correct and incorrect postures of a

keyboard user's hands/arms. When the warnings had two or four pictorials, they showed the correct posture and incorrect posture together. The incorrect postures were overlaid by either an "X" or circle-slash prohibition symbol. Participants were asked to estimate the percentage of people who would be informed and motivated by pictorials shown within each of the warnings.

METHOD

Participants

Twenty-four North Carolina State University undergraduate students between the ages of 18 and 20 participated ($M = 19.1$ years; $SD = 1.08$.) Nine of the participants were female.

Materials

Participants were given the following detailed background information about CTS:

"In recent years, reports of carpal tunnel syndrome (CTS) cases have increased in the U.S. Research indicates that carpal tunnel syndrome develops from improper positioning of the hands, wrists, and arms during prolonged periods of typing. Many people that develop CTS mistaken the symptoms for minor muscle fatigue and do not take the necessary precautions to avoid further damage to the muscles and nerves in their hands, wrists, and arms. If they were adequately warned they might recognize the disease before it becomes a problem."

Figure 1 shows the pictorials that were used in the study. The pictorials were shown within a rectangular warning containing a CAUTION signal word panel with a safety alert symbol (triangle enclosing an exclamation point) over a yellow background in the upper right corner. The area under the signal word panel was space reserved for the textual message component. To ensure that it did not influence a pictorial's rating, no warning message text was

given. It was filled with several lines of X's instead. The pictorials appeared on the left side of the warning. One of two prohibition symbols: a black "X" or a red "circle-slash" was superimposed over the incorrect hand/arm postures. The red circle-slash prohibition symbol was maintained in a fixed position at a 45° diagonal from the top left to the bottom right of the circle according to the guidelines of the ISO 3864 (1984) and ANSI Z535.2 (1991) public information symbol standard. The "X" was two black lines that crossed one another at a 45° angle. The number of pictorials in a warning affected the size of each of those pictorials. Four pictorial warnings had a smaller depiction of the hands, arms, and wrists than warnings containing one pictorial. This affected the size and location of the "X" over the incorrect postures on the warning. Placement of the "X" varied to ensure it did not cover areas of the hands, wrists, or arms that helped indicate the incorrect posture was being used. The stimuli were printed individually on 8.5 x 11 inch (21.6 x 27.9 cm) sheets of paper. The warnings containing four pictorials were approximately 6.9 x 3.5 inches (17.5 x 9 cm). Warnings with two pictorials were approximately 6.5 x 1.8 inches (16.5 x 4.5 cm) and the warnings with one pictorial were approximately 4.3 x 1.8 inches (11 x 4.5 cm).

Participants were asked to estimate the percentage of people that would comply with the pictorial message if it were located on or near a keyboard. The estimation task used a 100-point percentage scale where 0% (none) to 100% (all) was laid out from left to right in intervals of ten. A random letter of the alphabet was assigned to each pictorial and printed below it. Participants recorded their responses on a separate response sheet in a space adjacent to the corresponding letters that were arranged in alphabetic order.

Procedure

Participants were given a set of 12 simulated warnings containing one, two or four pictorials and asked to examine them. The ordering of the warnings was randomized for each participant. They were asked to make estimation judgments

according to the question and percentage rating scale described above.

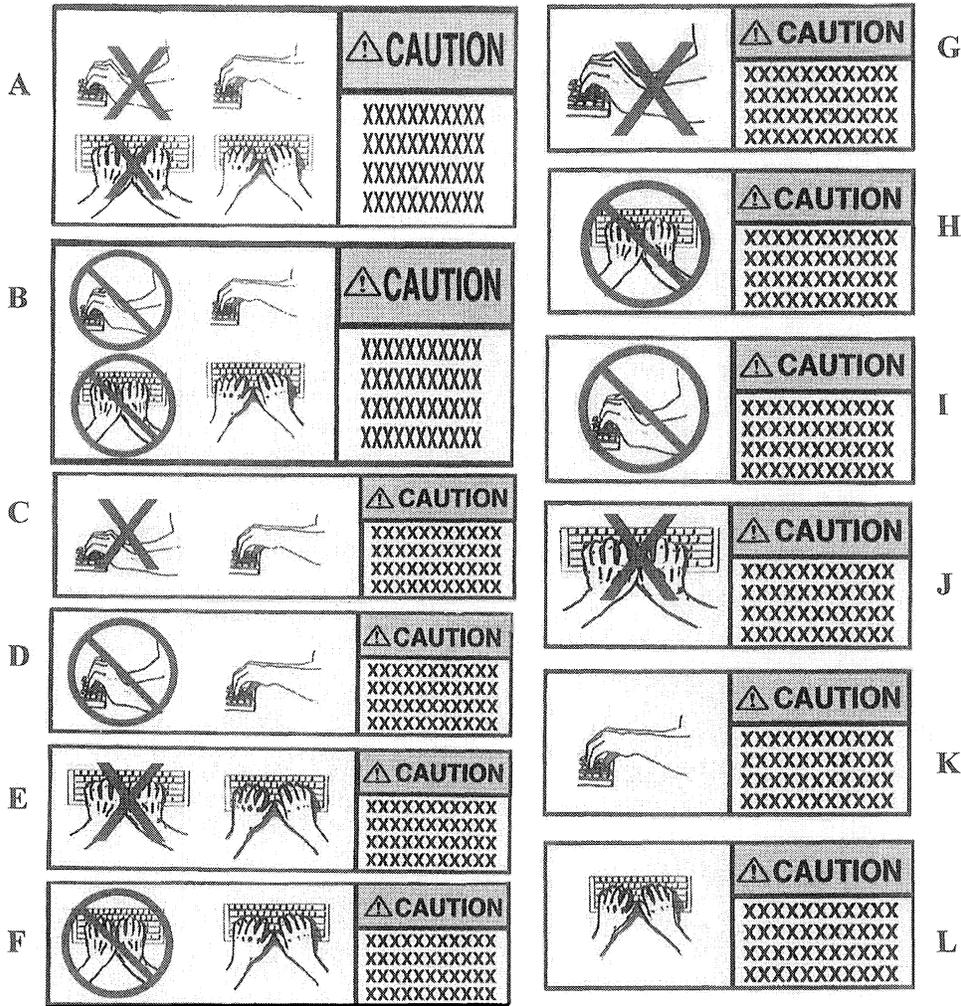
RESULTS

A description of the 12 pictorials used in the study and their respective means and standard deviations are shown in Table 1. Once the pictorials were placed in order according to their percent estimation mean, they were relabeled in alphabetic order as shown in Figure 1. There were three independent variables: Number of pictorials (4 vs. 2 vs. 1), View (top vs. side), and Prohibition symbol ("X" vs. circle-slash vs. none). Because the experiment did not comprise a complete three-factor design, all of the conditions could not be analyzed simultaneously in a single analysis. Therefore, a series of two factor repeated-measures models were applied to these data. Only the significant results are described here.

There were no statistically significant interactions between any pair of independent variables with the exception of one analysis described later. There was a significant main effect of the number of pictorials $F(2, 46) = 88.21, p < .05$. Comparisons of the means using Tukey's Honestly Significant Difference (HSD) test showed that warnings with four pictorials ($M = 77.7$) were given higher compliance estimations than warnings with two pictorials ($M = 50.9$), which were in turn higher than single pictorial warnings ($M = 28.8$). View yielded a significant main effect, $F(1, 23) = 9.45, p < .05$. The side views ($M = 54.7$) were rated higher than the top views ($M = 47.2$).

The prohibition symbol factor had a significant main effect, $F(2, 46) = 6.19, p < .05$. Tukey's HSD showed no difference between incorrect postures having the "X" ($M = 28.9$) and "circle-slash" ($M = 28.6$) overlays, but both were higher than the correct posture/no prohibition symbol condition ($M = 20.3$).

The only statistically significant interaction noted in the analyses was a 2(1 vs. 2 pictorials) X 2(side vs. top) view, $F(1, 24) = 4.91, p < .05$. Simple effects analyses showed that the side view ($M = 54.1$) was rated significantly higher than the top view ($M = 47.1$) when two pictorials



Condition	Number of Pictorials	View	Prohibition Symbol	Posture Shown	% Estimation Mean	Standard Deviation
A	4	Top/Side	X	Correct+Incorrect	78.54	15.21
B	4	Top/Side	C/S	Correct+Incorrect	76.88	16.86
C	2	Side	X	Correct+Incorrect	55.00	19.62
D	2	Side	C/S	Correct+Incorrect	54.38	18.84
E	2	Top	X	Correct+Incorrect	47.50	15.18
F	2	Top	C/S	Correct+Incorrect	46.88	21.46
G	1	Side	X	Incorrect	30.00	18.47
H	1	Top	C/S	Incorrect	29.38	19.24
I	1	Side	C/S	Incorrect	28.54	18.44
J	1	Top	X	Incorrect	27.29	19.28
K	1	Side	none	Correct	21.67	14.72
L	1	Top	none	Correct	18.96	14.82

Figure 1. 12 pictorial conditions and their respective % estimation means and standard deviations. Note: C/S = circle/slash; warnings not drawn to scale.

were presented but not when one pictorial was presented (side $M = 27.3$, top $M = 25.9$).

DISCUSSION

This research evaluated sets of pictorial symbols that might be included in a warning about CTS. The results showed that people believed that a warning containing four pictorials with both a top and side view and showing the correct or incorrect hand/arm postures is more effective than a subset of these symbols. This is not surprising since the four-pictorial warning gives more information to users on the proper and improper positioning of the hands and arms when using a keyboard. Multiple panel pictorials have the capability of communicating more contextual details and potentially more risk information than individual symbols (Kalsher et al., 2000).

In some cases, however, there may be restricted space to place a warning on a keyboard or monitor. If a four-pictorial warning is reduced to fit a small surface area, it may become illegible. The results suggest that if fewer pictorials are used, they should depict the incorrect posture with a prohibition symbol rather than the correct posture (without a prohibition symbol). These data indicate that neither prohibition symbol is preferred over the other. Since the ISO and ANSI recommend the circle-slash prohibition symbol, then it should probably be used unless there is some other reason to use the "X" (e.g., space constraints, pictorial obstruction, or cultural reasons).

This study investigates pictorial symbol effectiveness in a CTS warning and could be used to support whether similar results would be found when the same pictorials were presented to individuals who have been affected by carpal tunnel syndrome.

CTS pictorials perceived to be more effective in informing and motivating individuals to use the correct posture when performing tasks like typing could be combined with textual information to create a warning system that could be utilized in owner's manuals, posters, and on keyboards and other input devices (e.g., Freeman, Wogalter, Hink-Eustace & Frederick, 2001).

REFERENCES

- ANSI (1991). American National Standard for Environmental and Facility Safety Signs: Z535.2. American National Standards Institute, Washington, DC.
- Braun, C.C. & Shaver, E.F. (1999). Warning sign components and hazard perceptions. *Proceedings of the Human Factors and Ergonomics Society*, 43, 878-882.
- Dewar, R.E. (1976). The slash obscures the symbol on prohibitive traffic signs. *Human Factors*, 18(3), 253-258.
- Feldman, R.G., Travers, P.H., Chirico-Post J., & Keyserling, W.M. (1987). Risk assessment in electronic assembly workers: Carpal Tunnel Syndrome. *Journal of Hand Surgery*, 12a, 849-855.
- Frederick, L.J., Wogalter, M.S., & Hink, J. (1997). Prioritizing symptoms of CTDs for the design of warning labels. *Proceedings of the 13th Triennial Congress of the International Ergonomics Association Meeting, IEA '97*, 4, 268-270.
- Freeman, K., Wogalter, M.S., Hink-Eustace, J.K., & Frederick, L.J. (2001). Development of a warning system for Carpal Tunnel Syndrome. *Advances in Occupational Ergonomics and Safety*, 439-443.
- Fried, S.M. (1998). *Light as the End of the Carpal Tunnel*. East Norristown, PA: Healing Books.
- ISO (1984). International Standard for Safety Colours and Safety Signs: ISO 3864. International Organization, Switzerland.
- Kalsher, M.J., Brantley, K.A., Wogalter, M.S., & Snow-Wolff, J. (2000). Evaluating choking child pictorial symbols. *Proceedings of the IEA 2000/HFES 2000 Congress*, 4-790-4-793.
- Kinzie, S. (2001). Ergonomics urge. *News & Observer*, Raleigh, North Carolina, Tuesday, March 15, 2001, 1E.
- Loring, B.A. & Wiklund, M.E. (1988). Improving swimming pool warning signs. *Proceedings of the Human Factors Society*, 32, 910-914.
- Murray, L.A., Magurno, A.B., Glover, B.L., & Wogalter, M.S. (1998). Prohibitive pictorials: Evaluations of different circle-slash negation symbols. *International Journal of Industrial Ergonomics*, 22, 473-482.
- Sojourner, R. & Wogalter, M.S. (1997). The influence of pictorials on evaluations of prescription medication instructions. *Drug Information Journal*, 31, 963-972.
- Utnage, B. (1995). Carpal Tunnel Syndrome: Are you at risk? *Cyberhealth*, Dec. 7
- Wogalter, M.S., Godfrey, S.S., Fontanelle, G.A., Desaulniers, D.R., Rothstein, P.R., & Laughery, K.R. (1987). Effectiveness of warnings. *Human Factors*, 29, 599-612.
- Young, S.L. & Wogalter, M.S. (1990). Comprehension and memory of instruction manual warnings: Conspicuous print and pictorial icons. *Human Factors*, 32, 637-649.