Comprehension and Training of International Road Signs

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Interest in cross-cultural traffic signs is in part motivated by the increase of motorists driving in foreign countries. This study investigated comprehension levels of 100 international road signs and the effect of brief sign training with the associated referent (sign meaning) on subsequent comprehension. Using open-ended questions U.S. drivers were tested on their ability to correctly report the meaning and action associated with various international road signs. Later they were exposed to the textual referent in a brief 5 minute training exercise. Following the training exercise, comprehension was retested. For many signs initial comprehension levels were low and critical confusions (serious errors) were high. However, after a brief training session comprehension levels dramatically improved. The results indicate that U.S. drivers may have difficulty understanding traffic signage outside of the U.S. To some extent training of the sign meanings might counteract low comprehension and high critical confusions. More extensive training or redesign may be needed to ensure U.S. drivers understand particularly highly signs.

INTRODUCTION

Traffic control devices are instruments intended to provide proper notification of regulatory and warning information to motorists. One common method of traffic control is the use of posted signs. An important aspect influencing effective traffic control is people's understanding of them. Standard criteria for sign design include guidelines on placement, illumination, brightness, and appropriate colors (Chapanis, 1994; Droy & Shiner, 1982; Wolff, & Wogalter, 1998). A sign that is not understood not only fails to convey the appropriate message but also may generate confusion type errors that could result in diverting attention from the driving task.

Many countries have adopted a subset of the available international road signs (American Automobile Association, 2002; Auto Europe, 2003; Department of Transport and the Central Office of Information for HMSO, 2001; National Automobile Club, n.d.; Roads and Traffic Authority; 2002). These signs can present a problem for travelers who are not familiar with them. According to the U.S. Department of State (2004) only two organizations are authorized to issue international driving permits (IDP), both of which do not test U.S. drivers knowledge of foreign traffic signs when obtaining a permit. All that is required is proof of current drivers license, passport photos, and a $10 fee, then the IDP permit is valid in several countries for a period of one year (American Automobile Association, 2002; National Automobile Club, n.d.). The easy accessibility of international permits combined with rental car availability pose a safety risk if drivers on the road do not understand the meaning of the sign. One of the main questions of the present research is whether U.S. drivers understand road signs used in countries outside the U.S.

Comprehension is one of the most important measures of sign adequecy. The importance of comprehension is affirmed by a group of traffic sign experts and practicing traffic engineers from Australia, New Zealand, Canada, and USA who rated comprehension the most important criterion for adequate design of traffic signs (Dewar, 1988). Shinar et al. (2003) found that persons from different countries comprehend international signs at widely different levels. They recommend signs be standardized as much as possible and adhere to the following ergonomic design principles: spatial compatibility (direction of road sign maps with the direction given by the sign components), representation that has physical similarities to actual objects, and familiarity. Despite the European standardization of traffic signs in 1996, signs are not always understood by persons outside of the countries in which they are used, ultimately presenting safety concerns for a percentage of the global population (Shinar, Dewar, Summala, & Zakowska, 2003). Visiting foreign motorists are especially vulnerable to comprehension difficulties of posted traffic signs. In order for signs to be useful and promote safe behavior, motorists who do not know the local language must be able to understand posted signs. A study with over 3000 Texas drivers showed high levels of comprehension for certain U.S. traffic signs. However, several had low comprehension levels, indicating that their

associated safety message would not be adequately presented to drivers (Picha, Hawkins, Womack, & Rhodes, 1997). Numerous studies have found low comprehension levels for symbols (Caird, Wheat, McIntosh, & Dewar, 1997; Picha et al., 1997; Shinar et al, 2003). In order to improve the sign situation the design of symbols/signs should be based on iterative design principles together with input from samples of the target consumer. In this case the target consumers are motorists in different countries who are used to design and evaluate signs that people understand.

Another useful way to improve sign comprehension is to train people. A simple cost effective way to train would involve briefly displaying the sign and referent (sign meaning). Research indicates that such training can raise comprehension levels of pictorials that would not otherwise be understood (Wogalter, Sojourner, & Brelsford, 1997).

The present research evaluates comprehension levels of international road signs before and after a brief training procedure. It was hypothesized that the U.S. participants will initially have relatively low comprehension levels as per American National Standard Institute (ANSI) Z535.3 (2002) rating system criterion of 85% correct on an open-ended comprehension test. After a brief exposure to the sign and corresponding referent it was anticipated that comprehension levels would increase. Also of interest was the affect training would have on the occurrence of critical confusions (serious errors). The ANSI standard considers symbols with more than 5% critical confusion an unacceptable stand-alone safety sign (without words).

METHOD

Participants

A total of 100 individuals (60 females and 40 males, mean age = 22.02, SD = 9.06) comprised of 78 undergraduate students and 22 non-students from Raleigh-Durham area of North Carolina participated in the study. The only selection criterion was that participants had to have a valid drivers license.

Materials

Traffic signs. One hundred international road signs were selected from AAA and Auto Europe websites and Department of Transport Highway Code. Signs were then reproduced electronically retaining the same colors, symbols, and shapes using Photoshop 7.0 and Corel Draw 8. Because of the limited resolution of depictions signs were redrawn to remove jagged contours when signs were enlarged. Three judges (NCSU students in the Cognitive Ergonomics Laboratory) reviewed the signs separately to ensure clarity of referent descriptions obtained from the websites. The 100 signs were separated into 2 sets with 50 signs randomly assigned to group A or B. Signs were randomly assigned a number code printed in the upper right hand corner of the index card.

Other materials. The signs were printed separately on 3.5 x 5 inch (8.9 x 12.7 cm) white labels, which were then applied to 4 x 6 inch (10.16 x 15.24 cm) white index cards. Signs were approximately 3 x 3 inch (7.62 x 7.62 cm) when printed onto labels. Two sets of index cards were used when testing each participant. One set of index cards had the picture one side (other side was blank) while the other set had the picture on one side and the referent on the other side of the index card. In order to clarify the meaning of referent labels such as "Intersection with Tramway," a term for streetcar in British culture, a brief description of the sign such as "Tramway is British for streetcar" was placed below the label. More evident signs such as "Stop" received only the label. Cards were shuffled prior to each testing session. Participants were given 20 seconds to answer two questions for each sign: (a) *what do you think this sign means (what message is the sign trying to convey)?* and (b) *what action would you take in response to each sign?*

Procedure

A total of 100 international road signs were tested using two groups of participants, with each group exposed to only 50 of the signs (set A or set B). The session consisted of three phases: initial comprehension test, brief training, and post-training comprehension test. At the start of the initial comprehension test participants were first told that the signs they would see are signs they might encounter while driving in a foreign country. Participants were given the set of index cards with no referent or description on the back. To control the timing of sign presentation, a sequence of auditory tones signaled the participant to move to the next card. They were given 20 seconds to examine each card and record their answer. Participants matched the number code printed on the upper right hand corner of the index card to the corresponding number on the answer sheet.

In the brief training phase participants were given the same 50 signs as they had seen in the initial comprehension test. To facilitate an active learning process during training each participant was given a set of index cards that had the referent on the other side to study. They were given 5 minutes to look at the cards anyway they wished. Generally it appeared that participants reviewed the index cards at their own pace and spent time learning unfamiliar signs. In order to ensure that most or all of the signs were reviewed a timer signaled an auditory tone one minute prior to the end of the training period. In the post training comprehension test participants were retested using the same procedure used in the initial comprehension test except that signs were in a different random order. Participants were tested in groups of four or less.

RESULTS

A set of comparisons of comprehension performed before and after trainings was conducted. Participant responses were scored by three separate graders into one of two categories: correct (1) or incorrect (0). Incorrect answers were also examined for the presence of critical confusions. Answers were designated as critical confusions when the opposite answer was given or the stated action would be unsafe. For example, the answer 'no taxi parking' would count as a critical confusion for the sign 'parking for taxi's only.' An example of an unsafe action counted as a critical confusion would be a response that, if enacted, might result in injury. According to ANSI Z535.3 Safety Symbol Standard (2002) stand alone symbols (without accompanying words) must receive a score of 85% correct and no more than 5% critical confusion on a comprehension test that is administered to 50 participants. ANSI standards were chosen as the acceptability criteria for this study due to the perceived compatibility with the U.S. population.

Both the overall score of the answer (correct or incorrect) and the presence of critical confusion were examined. Initially three judges (NCSU students from the Cognitive Ergonomics Laboratory) were given the meaning of symbols and referents to serve as clarification. They

10 Lowest

Sign	Referent	Initial correct	Initial critical confusion	After Training correct	After Training critical confusion
	unguarded railroad crossing	0%	0%	72%	0%
	expressway entrance	0%	0%	60%	0%
	holiday route	0%	0%	54%	0%
	priority road	0%	0%	46%	0%
	end of prohibition of passing	0%	16%	48%	28%
	no parking side 1-odd days, side 2-even days	0%	0%	80%	0%
	vehicles may pass	2%	0%	46%	2%
	goods vehicles passing prohibited	2%	0%	38%	8%
	end of all local vehicle prohibitions	2%	0%	62%	0%
	road closed	2%	2%	46%	0%

10 Highest

Sign	Referent	Initial correct	Initial critical confusion	After Training correct	After Training critical confusion
	parking area	90%	2%	94%	0%
	road works	92%	0%	98%	0%
	bicycle path	92%	0%	96%	0%
	no power-driven vehicles	92%	0%	90%	0%
	cyclists crossing	94%	2%	94%	4%
	light signals	94%	0%	98%	0%
	meter parking	94%	0%	98%	0%
	stop	96%	0%	100%	0%
	hospital	98%	0%	100%	0%
	airfield	98%	0%	98%	2%

Figure 1 Ten signs with the lowest and highest comprehension score during the init ial test. Percentage of comprehension scores and critical confusions are displayed for both initial and after training tests.

examined the responses given by participants and made judgments of correct or incorrect. The inter-rater reliability coefficient among raters was r =.91. When all three judges did not agree on the scores a majority rule between the judges was applied to arrive at the comprehension scores reported in this study.

Sign Comprehension

Initial Comprehension Test. Figure 1 shows the results (comprehension score and critical confusions) for 10 signs that received the lowest comprehension score and 10 signs that received the highest comprehension score, only a portion of the complete list of signs is shown due to space limitations. Overall, 40% of responses (across all signs) were correctly identified in initial testing phase. In other words, 60% of responses (across all signs) given were incorrect answers. There were large differences in comprehension among various signs, ranging from 0% to 98%. Figure 1 shows that there were 6 signs that were not answered correctly by any of the participants. Only 17 out of 100 signs met the ANSI criterion of 85% correct. Critical confusions occurred above 5% for 16 signs. Figure 2 shows a subset of the signs with high levels of critical confusions.

Post-Training Comprehension Test. Across all participants 82% of responses were correct in the post-training test. Thus the number correct overall in the post training test was doubled compared to the initial training test. This difference is significant, $F_{(1, 198)} = 105.13; p < .0001$.

There were 58 out of 100 signs correctly identified by a mean score of 85% or more in the post training test. A total of 81 signs were correctly identified by an average of 67% of responses. An increase in overall comprehension levels during the post-training test was accompanied by a significant decrease in the number of critical confusions of more than 5% from 16 during initial testing to 12 during final testing, $F_{(1, 198)} = 6.52; p < .01$. For example, prior to training there were numerous critical confusions for the open red circle, which were frequently judged as permissive as opposed to prohibitive. The training helped decrease the open red circle critical confusions from 39% to 6% from the initial testing to final testing.

DISCUSSION

Road signs are intended to convey regulatory and warning information to motorists. However, the present results indicate that U.S. drivers do not comprehend a relatively large number of the international road signs. Without proper training of the international road signs, U.S. drivers pose a serious safety threat to themselves and others when driving in other countries that use international signs to post warnings and regulations. Sign comprehension was initially low with only 17 of 100 signs meeting the 85% comprehension level of the ANSI Z535.3 (2002) standard. However, sign training did increased the number of signs meeting or exceeding the ANSI criteria to 58 of the 100

Sign	Referent	Initial correct	Initial critical confusion	After Training correct	After Training critical confusion
	no cycling	4%	92%	94%	6%
	no pedestrians	6%	88%	92%	6%
	parking for taxi's only	8%	86%	96%	4%
	no mopeds	6%	70%	80%	6%
	no motor vehicles	4%	64%	88%	2%

Sign	Referent	Initial correct	Initial critical confusion	After Training correct	After Training critical confusion
	road narrows	42%	32%	88%	8%
	dangerous descent	36%	28%	68%	10%
	end of prohibition of passing	0%	16%	48%	28%
	no stopping	6%	8%	62%	2%
	parking on sidewalk permitted	32%	8%	92%	4%

Figure 2 Ten examples of signs with critical confusions.

signs.

There appears to be many critical confusions resulting from the prohibitive red circle, but training dramatically reduced these errors. Prior to training many of the participants believed the open red circle to be permissive with respect to the displayed internal symbol when in fact the red circle means prohibition or restriction (even without the slash typically used in U.S. prohibition symbols).

The following conclusions can be drawn from this study: Foremost, international road sign comprehension can and should be improved through methods of design and evaluation that are well documented in the human factors/ergonomics (HF/E) literature. If existing signs cannot be improved then training should be conducted. Effective training can be brief, active, and can produce relatively rapid results. However, training should not substitute for the use of better designs when they can be made. Unfortunately, training cannot be expected to reach everyone unless incorporated into license testing and driver education made available through the mass media. HF/E principles suggest that it is better at the outset to develop good signs based on testing and iterative design to ensure proper understanding.

Signs should be easy to interpret by motorists. Adequate sign development is necessary to ensure that travelers foreign to the culture do not need training because it can be anticipated that everyone will not get trained. But given an existing set of signs already in place, training should benefit comprehension. Agencies providing international driving permits should consider providing training and testing of motorists so that permit holders comprehend signage posted on roadways in foreign countries.

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