

Evaluating the Clarity of Highway Entrance-Ramp Directional Signs

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Abstract

Near the approaches of interstate and other major highways, posted directional signs warn drivers about the proper lanes for entering these high-speed limited-access roadways. These signs are intended to guide drivers with clear, concise directions, but they may instead expose drivers to ambiguous information. This ambiguity has the potential for causing accidents when the wrong lane is chosen and the driver must cross several lanes of traffic in these frequently busy interchanges. The present study examined the effectiveness of currently used interstate entrance-ramp directional signs, as well as a set of systematically manipulated alternative signs. Participants examined 94 sets of signs having various forms of simple vs. complex arrows and text (both alone and together) and for each, they were to indicate the appropriate lanes and direction to enter the interstate highway. Participants also rated the same signs according to clarity. Results indicated that text alone and text plus arrow signs consistently produced better performance and higher clarity ratings compared to signs containing arrows alone. No differences were found in the set of text statements investigated. However, differences were found for the arrow alternatives. Simple arrows (both alone and with text) produced better performance and higher clarity ratings compared to complex arrows. The data show that the current highway signs are ambiguous, and that there are alternative designs that are clearer. In real-world applications, improved signs may reduce accident rates by decreasing decision errors.

INTRODUCTION

Traffic control devices are intended to guide motorists with clear and concise information, and alert motorists to unusual and confusing traffic patterns. Highway entrance-ramps are areas where clear and concise information is needed to guide motorists to the appropriate lane so they can make safe entries onto highways. Ambiguity in highway entrance signs has the potential for causing accidents. This ambiguity could cause drivers to miss an entrance-ramp or force drivers to make an unsafe driving maneuver. While research has been conducted to investigate the best method of presenting information on roadway signs (text versus symbolic), the results appear to be dependant on the type of information being conveyed and the particularities of the research methodology employed.

Research assessing response times to general traffic signs and directional signs has reported some conditional findings. Some research (Dewar, Eells, & Mundy, 1976; Kline, Buck, Sell, Bolan, & Dewar, 1999; Kline, Ghali, Kline, & Brown, 1990; Whitaker, & Stacey, 1981) has reported faster responses to

icons and arrows, whereas other research (Dewar, Eells, & Mundy, 1976; Shoptaugh & Whitker, 1984) has indicated faster responses to text. Reports of faster verbal responses to text signs compared to symbolic signs have been explained by experimental conditions employed in the research. Faster responses to text signs disappear when visibility is degraded. Another explanation for the response advantage to text signs is that verbal responses are more compatible with text compared to symbolic signs (Kline, Buck, Sell, Bolan, & Dewar, 1999; Shoptaugh & Whitker, 1984).

Figure 1 illustrates one of the signs currently used in the U. S. While there is clear guidance as to which lane the driver needs to be in to enter the highway to travel west, information concerning travel to the east is ambiguous. Drivers might need to be in the right lane to enter a clover leaf, or drivers might need to be in the left lane to turn onto a straight access ramp. Ambiguity like this has the potential for causing accidents when the wrong lane is chosen and the driver must cross several lanes of traffic.

When considering the best way to present directional information on interstate entrance-ramp signs, there are a number of alternatives. Signs that

include arrows alone offer simplicity that is supported by a Gestalt view concerning ease of processing. However, ambiguity in these signs may be problematic due to lack of necessary features. Signs that include text alone offer a means for clear and concise directions. However, under degraded conditions text may become difficult to process (Dewar, Ells, & Mundy, 1976; Kline, Buck, Sell, Bolan, & Dewar, 1999). Signs that include both text and arrows provide redundant information that might ease the driving workload or might create visual clutter thus increasing the driving workload. The present experiment investigated the clarity of text only, arrow only, and text + arrow directional signs, including the current and a set of alternative signs.

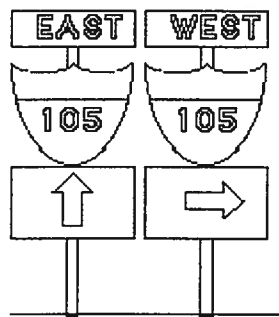


Figure 1. Example of currently used interstate entrance-ramp directional sign.

METHOD

Participants

Twenty-four licensed drivers (mean age = 28, ranging from 18 to 46 years) participated. The participants were recruited from an undergraduate introductory psychology course at North Carolina State University and from a local shopping area. Participants from the psychology class received course credit for their participation. Participants from the local shopping area received small gifts comprised of memorabilia from a local university.

Stimuli

Line drawings depicting current and alternative interstate entrance-ramp directional signs were used. Each sign consisted of a sign pair containing information indicating the appropriate direction to enter the highway to travel east or west. See Figure 1 for an example of an Arrow Only sign used in the experiment.

Text Only Stimuli

Text Only signs consisted of text statements instructing drivers which lane to be in so as to enter the interstate to travel east or west. The actual statements were chosen based on pilot experiments. Two sets were created to counter-balance "left lane" and "right lane" correct responses. For left turns the statements were: Left Lane, Enter Left, Next Left, 1st Left, and Left After Bridge. For right turns the statements were: Right Lane, Enter Right, Next Right, 2nd Right, and Right After Bridge.

Arrow Only Stimuli

Arrow Only signs consisted of block arrows instructing drivers which lane to be in so as to enter the interstate to travel east or west. The arrow stimuli were chosen based on pilot experiments. Two sets were created to counter-balance "left lane" and "right lane" correct responses. Arrow alternatives included simple, moderate, and complex arrows. Examples are shown in Figures 2 to 4. Simple arrows consisted of arrows with no "gaps" or "crossings," moderate arrows contained a "gap" or a "crossing," and complex arrows contained multiple "gaps," "crossings," or both. Seven left/right alternative arrows were investigated.

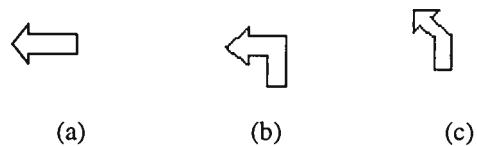


Figure 2. Examples of Simple Arrows.

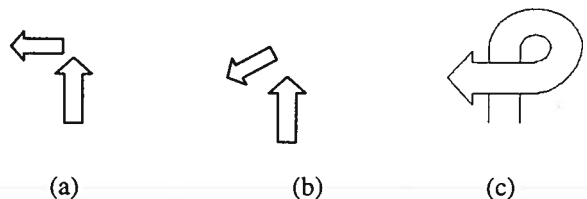


Figure 3. Examples of a Moderate Arrows.

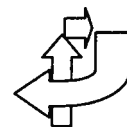


Figure 4. Example of a Complex Arrow.

Text+Arrow Stimuli

Text+Arrow signs consisted of combination text and arrows instructing drivers which lane to be in so as to enter the interstate to travel east or west. The stimuli were created by combining text and arrow alternatives. Eighty Text+Arrow alternatives were investigated.

Procedure

Each participant was given a packet containing the 94 signs. Each sign was on a separate page. The order of presentation of the signs was different in each packet. Participants were instructed to imagine themselves approaching a highway entrance and seeing the sign illustrated in the packet. Participants were instructed to view each sign and indicate which lane they needed to be in so as to enter the highway heading east.

Participants used a response sheet to record their responses. After indicating the direction, participants were asked to rate the clarity of the sign based on a rating scale from 0 to 8 (0 meaning "not clear at all" and 8 meaning "extremely clear"). Participants completed the task individually and at their own pace. Upon completion of the task, participants were debriefed, thanked, and released.

RESULTS

Response Accuracy

In order to evaluate the response accuracy to the signs, a one-way repeated measures Analysis of Variance (ANOVA) on sign type was conducted. The dependent measure was mean percent correct averaged across signs for each sign type. Three sign types were compared: Text Only, Arrow Only, and Text+Arrow. A significant effect of sign type was found, $F(2, 46) = 37.50$, $p < .0001$. Subsequent paired comparisons revealed significantly higher response accuracy for Text+Arrow ($M = .92$) and Text Only ($M = .90$) signs compared to Arrow Only ($M = .70$) signs ($p < .05$).

Clarity Ratings

In order to evaluate the clarity of the signs, a one-way repeated measures ANOVA on sign type was conducted. The dependent measure was mean clarity rating. Ratings were averaged across signs for each sign type. Three sign types were compared: Text Only, Arrow Only, and

Text+Arrow. A significant effect of sign type was found, $F(2, 46) = 13.16$, $p < .001$. Subsequent paired comparisons revealed Text+Arrow ($M = 5.62$) and Text Only ($M = 5.37$) signs were assigned higher clarity ratings compared to Arrow Only ($M = 4.62$) sign pairs. Clarity ratings for Text+Arrow and Text Only signs did not differ.

Paired t-tests with a Bonferroni correction were conducted to determine the clearest text and the clearest arrow. There were no differences in the text phrases used in Text Only or Text+Arrow signs. For Text+Arrow signs scores were collapsed over text statements (there were no differences in text statements) in order to more closely evaluate the influence of the alternative arrows. Differences emerged for the alternative arrows ($p < .01$). The pattern of results was similar for Arrow Only signs and for Text+Arrow signs. In general, three groups were formed by the transition from simple arrows, with no "gaps" or "crosses," to moderate arrows, with one "gap" or one "cross," to complex arrows, with combinations of "gaps" and "crosses." The mean clarity rating for the highest rated simple arrows was 5.74. The arrows comprising this group were the left and right turn versions of the simple arrow illustrated in Figure 2b and the left turn version illustrated in Figure 2c. The mean clarity rating for the moderate arrows was 5.30. The mean clarity rating for the complex arrows was 3.50. These means were calculated by collapsing over Arrow Only and Text+Arrow signs.

The simple arrows from the Text+Arrow signs ($M = 5.74$) were given significantly ($p < .005$) higher clarity ratings than the corresponding simple arrows appearing on the Arrow Only signs ($M = 5.33$).

The only exception to the pattern of simple arrows being rated with high clarity compared to more complex arrows was with the currently used Arrow Only sign illustrated in Figure 1. The currently used sign resulted in low response accuracy ($M = .45$) and was rated low in clarity ($M = 3.29$).

DISCUSSION

The present study examined the response accuracy and clarity of currently used interstate entrance-ramp directional signs, as well as a set of systematically manipulated alternative signs. Signs containing text +arrows and signs containing text alone were clearer compared to signs containing arrows alone. This finding was supported in both response accuracy and clarity ratings. Participants responded correctly to over 90% of the signs

containing text+arrows and text alone, whereas, they responded correctly to only 70% of the signs containing arrows alone. Consistent with the response accuracy, participants rated signs containing text+arrows and text alone as being clearer compared to the signs containing arrows alone.

By systematically manipulating the text and the arrows, it was possible to evaluate the alternative text statements and arrows. Based on the clarity ratings, there were no differences in the simple, concise text statements investigated regardless of whether the text appeared alone or with arrows. However, there were differences among the arrow categories. Simple arrows with no "gaps" or "crosses" were rated as clearer compared to moderate and complex arrows. Moderate arrows with one "gap" or one "cross" were rated as clearer compared to complex arrows with multiple "gaps" and/or "crosses." This clarity rating pattern emerged for arrows appearing with text and arrows appearing alone.

Text+arrow signs and text alone signs were rated as clearer than arrow alone signs. This finding suggests that using text in highway entrance-ramp signs would be beneficial. However, sometimes text on signs becomes difficult to process because of environmental conditions that reduce that reduce legibility. With the text+arrow signs the availability of redundant symbolic information continues to provide drivers guidance.

In determining the best arrow to include in a text+arrow highway entrance sign, our results suggest that simple arrows are better than more complex arrows. Simple arrows included in text+arrow signs were rated the highest of all the signs tested. The corresponding arrow alone (simple) signs were not rated as high in clarity. Based on this finding, participants appear to gain clarity from the redundant information provided by text and simple arrows, again arguing for the use of text+simple arrow signs.

Care must be taken in choosing the simple arrow to appear on a text+arrow highway entrance sign. The simple arrow must provide clear guidance. The currently used highway entrance sign illustrated in Figure 1 contains a simple arrow with no "gaps" or "crossings." However, this arrow is ambiguous. To enter the highway to travel east, the driver might need to be in the right lane to enter a clover leaf or the driver might need to be in the left lane to turn onto a straight access ramp. Instead

of the currently used simple arrow, a different simple arrow that provides clear guidance should be used. The arrows rated the clearest in this experiment are illustrated in Figures 2b and 2c. These arrows not only provide information concerning the proper lane to be in, but the arrows also indicate that the driver needs to drive straight before turning. Thus, when selecting an arrow to appear on an entrance sign, simple arrows that provide the most explicit information appear to be the best alternative.

Based on the findings of this experiment, the clearest highway entrance signs are text+arrow signs with simple arrows that provide both concise and explicit information. Potentially, drivers can rely just on the text. However, when the text becomes difficult to process because of environmental conditions that reduce legibility, the availability of symbolic information will continue to provide drivers guidance. Thus the present research suggests that highway entrance-ramp signs can be improved. Future research aimed at quantifying the benefits and cost of providing redundant highway entrance direction information will aid in identifying the best way to guide motorists with clear and concise information.

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