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THE PERCEPTION OF LINGUISTIC AND NONLINGUISTIC INPUTS: THE CASE OF ROAD SIGNS

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THERE HAVE BEEN A NUMBER OF STUDIES INVESTIGATING DIFFERENCES in the perception of linguistic and nonlinguistic inputs. These studies have taken many different forms, focusing on phenomena as diverse as infant reactions to sounds, the effects of brain injuries, and dichotic listening experiments (for some early examples, see Catlin & Neville 1976; Jusczyk *et al.* 1977; Morse 1972; Oscar-Berman, Goodglass & Donnenfeld 1974; Soderquist & Hoeningmann 1973; Wood, Goff & Day 1971, among many others), but they have generally found that there are differences in the way humans process, for example, a word as opposed to a bird's chirp. In nearly all cases, however, these look at reactions to linguistic inputs as they are generally found in the ordinary course of hearing language as compared to parallel nonlinguistic stimuli.¹ However, there are many cases in which linguistic stimuli are encountered in other situations, and in this paper we focus on one of these: road signs.

1. ROAD SIGNS. Road signs are generally standardized along four dimensions to offer information to motorists: shape, color, symbols, and text (Hawkins 1992; Federal Highway Administration 2007). Three of these four are nonlinguistic, and all road signs do in fact contain nonlinguistic information, because all of them are differentiated into categories through the use of shape and color, which then have symbols, text, or both added to specify the particular sign within that category. **Figure 1** (overleaf), for example, shows three road signs that contain no linguistic information: from left to right, a SCHOOL CROSSING sign, a NO RIGHT TURN sign, and a PEDESTRIAN CROSSING sign.²

In **Figure 2** (overleaf), on the other hand, we see four signs that contain both linguistic and non-linguistic information. From left to right, the STOP and SPEED LIMIT signs are dif-

¹ Some similar effects have been found for visual stimuli. For reports of studies that explicitly compare linguistic and visual processing, see Yund, Uno & Woods 1999 and the survey in Polka, Jusczyk & Rvachew 1995; for a more general discussion of the combination of linguistic and non-linguistic material into multimodal texts, see O'Toole 1994 and Kress & van Leeuwen 2001.

² To easily distinguish between the name of a sign and descriptions of those signs or their contents, we have placed the colloquial names for the road signs we discuss in small caps, so that a STOP sign is a red octagon containing the word *stop*. We caution that some colloquial names for signs are somewhat ambiguous as to content—for example, a SLIPPERY WHEN WET sign is always a diamond, but may be yellow or orange (depending on whether it's in a construction zone or not) and can contain either the words *slippery when wet* or a symbol denoting the same—but this does not cause a problem for the signs we focus on in this paper. Note that all signs in actual use that are discussed in this paper are outlined in detail in Federal Highway Administration 2007.



Figure 1. Three road signs containing only nonlinguistic information.

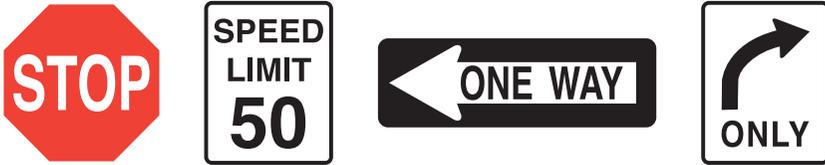


Figure 2. Four road signs containing both linguistic and nonlinguistic information.

ferentiated by shape and color (a red octagon for the STOP sign, a black-bordered white vertical rectangle for the SPEED LIMIT sign), but also contain text (including, in the case of the SPEED LIMIT sign, numbers). The ONE WAY and RIGHT TURN ONLY signs are also defined by shape and color (respectively, a black-bordered horizontal arrow and a black-bordered white vertical rectangle) and contain text, but they also contain symbols (a large white arrow on the ONE WAY sign and a black right turn arrow on the RIGHT TURN ONLY sign).

None of this is terribly surprising, of course. Neither is it surprising that some of these elements consistently go together: A STOP sign, for example, is always octagonal and red, and (in most of the English-speaking world) contains the word *stop*. In other cases, the connections are not as consistent: a diamond-shaped sign, to use one specific case, may be yellow, orange, or yellow-green, and may have any number of symbols or words on it, depending on the particular situation a motorist in that area is likely to face. However, even in cases lacking such consistency, there are still limits: A diamond-shaped sign, for example, is never red, nor can it ever contain phrases such as *speed limit* or *go*. Similarly, signs reading *stop* are never colored green, and the word *yield* never appears on pentagonal signs.³

2. ISSUES AND METHODOLOGY. The design of road signs is particularly important when one considers that it has an impact on public safety—if drivers can't properly interpret the content of road signs, then safety is impacted negatively, because drivers are likely to do the wrong thing in response. In fact, some of the redundancy in road signs was designed with

³ All of these descriptions are based on the conventions for road signs as they are found in the United States. Other jurisdictions have different norms for road signs, of course, but since the respondents to our survey (as we discuss elsewhere in the paper) had nearly all driven only in the United States, we have opted to keep our focus here and elsewhere on the signs they have regularly come in contact with.



Figure 3. Nonstandard road signs differing from standard signs in shape, color, symbol, or text.

this in mind. For example, downward-pointing triangles are only ever used for *YIELD* signs so that even if the word *yield* and the red border on the sign becomes illegible (perhaps due to vandalism or fading from exposure to sunlight) motorists can still recognize it as a *YIELD* sign (Hawkins 1992). Given all of this redundancy, though, we are led to five basic questions:

1. Are linguistic and nonlinguistic components of road signs interpreted differently?
2. For signs with both linguistic and nonlinguistic elements, can the perception of the linguistic components be overridden by nonlinguistic ones, or vice versa?
3. Do drivers know what combinations of color, shape, symbol, and text actually exist on road signs?
4. Does the internal redundancy of road signs reduce confusion?
5. How can road signs be improved for safety?

Our ultimate goal, naturally enough, is finding an answer to (5). However, before getting to that in any meaningful way we need to be able to answer the others; since the study we present here is an initial pilot study, we focus primarily on questions (1) and (2).

To answer these questions, we conducted a survey of individuals' interpretations of road signs. The survey consisted of eighty-eight road signs, some of which were standard road signs in actual use while others were based on standard road signs but with their shape, color, symbol, or text altered. Examples of some of these non-standard signs are given in **Figure 3**: from left to right, a *SPEED LIMIT* sign that has a horizontal rectangle shape instead of a vertical rectangle, a *DO NOT ENTER* sign that is green instead of red, a *SCHOOL CROSSING* sign with the standard symbol replaced with the symbol from a *PEDESTRIAN CROSSING* sign, and a *STOP* sign that reads *yield* instead of *stop*.⁴

In addition, the survey included what we call "blank" signs. Since all of the standard road signs we included in our survey always contain symbols or words, we presented versions of them that did not include such content, as well as versions of the non-standard signs we used without content. Examples of these are given in **Figure 4** (overleaf): from left

⁴ Because of the highly redundant nature of road signs, of course, some of these could be analyzed differently. For example, among the nonstandard signs in **Figure 3**, the yellow pentagon could be analyzed as a *PEDESTRIAN CROSSING* sign in a pentagonal instead of a diamond shape, and the red octagon as a *YIELD* sign using an octagon instead of a downward-pointing triangle. This ambiguity is ultimately unimportant for the discussion at this point, however.



Figure 4. Examples of blank signs used in the survey.

to right, a STOP sign without the word *stop*, a ONE WAY sign without the phrase *one way*, a green (rather than red) version of a YIELD sign without the word *yield*, and a black (rather than red) version of a DO NOT ENTER sign omitting the phrase *do not enter*. Of these, the first two are blank versions of standard signs, while the last two are blank versions of non-standard signs presented elsewhere in the study.

The survey respondents were presented with all eighty-eight signs in the survey in a random order, except that the blank signs were presented before the signs with symbolic or linguistic content.⁵ This was done because the symbols and words used on the signs with such content were limited to only a few possibilities, and (in case symbolic or linguistic information could alter perceptions of the meaning of the shapes and colors of the signs) we wanted to avoid the danger of preconditioning the respondents' reactions by initial exposure to such content.

For all of the road signs (standard, nonstandard, and blank) in the survey, the respondents were individually presented with an image on a computer screen and asked to give the meaning of the sign, where the sign would be found, and whether the sign was a real road sign. The last of these was answered by respondents checking radio buttons, but the first and second were free response items. Questions could be skipped (although the respondents were not directly informed of this fact), but once skipped or answered the questions could not be revisited. The respondents were allowed as much time as they liked to answer the questions.

We should note that there are two important limitations resulting from this approach. First, we could not assess reaction times because some of the questions involved open-ended responses, which meant that we could not gauge reaction times given variations in typing speed, length of answers, and so on.⁶ Second, as discussed elsewhere in this paper, the presentation of signs was unnatural when compared to the way drivers encounter road signs while driving. However, since this was a pilot study set up in part to determine what variables we should focus on in further studies of this topic where we could present partici-

⁵ Another exception to the randomness of the order was that the first sign was consistently a blank red octagon. This was done in the hope that presenting the respondents with a relatively familiar sign would allow them to ease into answering the survey questions more readily.

⁶ The open-ended responses and non-open-ended responses could have been presented separately, but we opted to present the respondents with all of the questions for any given sign at once. This is, perhaps, non-optimal, but it was done largely because this approach is in line with earlier surveys on similar issues (most particularly Ford & Picha 2000 and Hawkins, Picha & Lopez 1998). We plan that future studies following up on this pilot study will include measures of respondent reaction time.



Figure 5. Road signs with completely redundant shape, color, and text.

Sign	Shape	Color	Text
RAILROAD CROSSING	Crossbuck	White	Railroad crossing
ONE WAY	Horizontal arrow	Black (with white arrow)	One way
STOP	Octagon	Red	Stop
YIELD	Downward-pointing triangle	Red (with white triangle)	Yield
DO NOT ENTER	Squared circle	Red (with white border)	Do not enter

Table 1. Linguistic and nonlinguistic content of standard forms of analyzed signs.

pants with road signs in a more realistic setting, and since similar surveys have been used successfully in previous studies of road signs (see, for example, Ford & Picha 2000 and Hawkins, Picha & Lopez 1998), we opted for this approach here.

The panel was made up of forty-six students in introductory undergraduate linguistics classes; we had planned to exclude any respondents who had a background in civil engineering, but that issue never arose. Before the respondents took the survey itself, we obtained limited demographic information, most importantly what parts of the world they had lived in, as well as what parts of the world they had driven or been licensed to drive in. The vast majority of the panel, as it turned out, had similar histories: They were all residents of the United States (and were licensed to drive in the United States), and very few had driven (or even visited) locations outside of the United States. Since the few that had been outside of the United States appeared to pattern with the rest of the respondents, we left them in our sample.

3. SIGNS ANALYZED. Since we are looking at potential differences between linguistic and nonlinguistic perception here, in this paper we focus on a set of five signs that (in their standard forms) are completely redundant with regard to shape, color, and the text they contain. These signs are shown in Figure 5; from left to right, the RAILROAD CROSSING sign, the ONE WAY sign, the STOP sign, the YIELD sign, and the DO NOT ENTER sign. Table 1 shows the content of these five signs; note that the shape and text of each sign is redundant (e.g., all crossbucks contain the text *railroad crossing*, and all signs that read *do not enter* are squared circles), and the color of each sign follows from the shape and text.

Here, we present an analysis of the interpretation of these signs when they were presented with various phrases. The phrases we presented with each of these signs are shown in

Sign	Phrases used
RAILROAD CROSSING	Railroad crossing, [blank]
ONE WAY	One way, stop, go, [blank]
STOP	Stop, yield, go, [blank]
YIELD	Yield, stop, go, [blank]
DO NOT ENTER	Do not enter, enter, [blank]

Table 2. Phrases presented on each analyzed sign.



Figure 6. The red octagon in various forms, as seen by the survey respondents.

Table 2.⁷ To give a more concrete picture of what these looked like, **Figure 6** shows the red octagon with all four phrases used with that shape-color combination. Note that, because this pilot analysis only covered the perception of textual content (or lack of content) on the five tested signs that are completely redundant in terms of form and content in actual use, in this paper we are presenting results for only fifteen of the eighty-eight signs that the survey respondents were faced with.⁸

4. THE INTERPRETATION OF ROAD SIGNS. We start out by looking at the panelists' interpretation of signs on a purely linguistic basis, without looking at the shapes or colors of the signs that the phrases appeared on, to see if certain phrases had a stronger effect on perception.⁹ This was done by coding whether the responses the panelists gave for the meanings of the signs matched the wording on the signs (e.g., responses of "stop" or "pause before going further" were counted as matching the wording *stop*), regardless of the nonlinguistic content of the signs they appeared on; responses expressing nothing but confusion or uncertainty were not included in the counts. The results for all of the responses for signs

⁷ A glance at **Figure 2** reveals that we did not test every possible phrase combination for every sign. This is simply the result of the fact that some phrases couldn't fit on a sign shape and still look like an actual possible road sign—consider, for example, the phrase *railroad crossing* on a downward-pointing triangle (particularly using the relatively small font used on YIELD signs), or the impossibility of placing the word *stop* on a crossbuck. This limited the combinations we could present to the respondents.

⁸ We do note, however, that the initial results of additional testing on a different set of these of signs has confirmed the results described in this paper (Bowie & Bowie 2009).

⁹ It is impossible, of course, to completely separate the phrases that were used from the shapes and colors of the signs they appeared on, since there were cases like the phrase *railroad crossing*, which only appeared on a white crossbuck. Because of this, one should keep in mind that the analysis of the perception of phrases here is only a first approximation of what was going on.

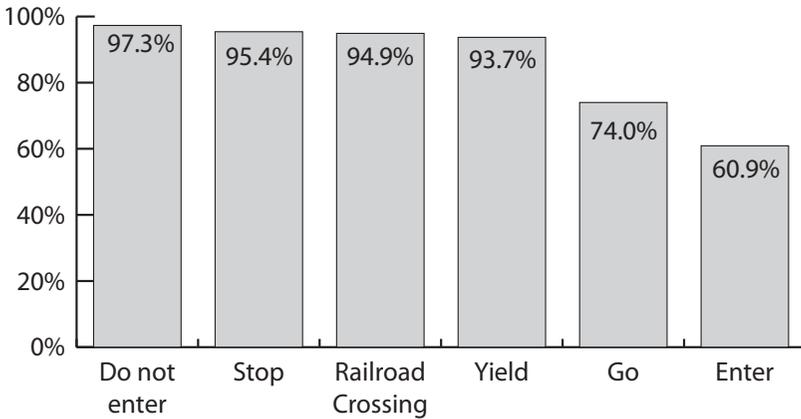


Figure 7. Interpretation of signs, by sign phrasing.

with linguistic content are given in **Figure 7**, in terms of the percentage of responses that matched the linguistic content of the sign.

It appears at first that there is a split between phrases that do not normally appear on road signs (*go* and *enter*) on the one hand and those that do on the other, but it turns out that the differences shown here are not statistically significant, possibly due to distributional issues.¹⁰ These results are intriguing, though, and so we intend to investigate this more deeply in the future, but for now there is nothing more to say about this beyond the lack of a finding.

Given this result, it is clear that we need to look at each specific sign shape to see whether linguistic content made a difference in the interpretation of those signs. We begin by looking at the crossbuck, which is consistently used for the RAILROAD CROSSING sign. This was only presented as a blank sign and as one reading *railroad crossing*, since the shape of the sign made it difficult to produce realistic-looking signs with other phrases. The results for the panelists' interpretations are given in **Figure 8** (overleaf); here, the percentages given are the percentage of panelists giving responses that matched the shape of the sign (i.e., identifying it as a RAILROAD CROSSING sign).

Once again, however, these results show no statistically significant difference.¹¹ In this case, though, the reason is not due to a sample size problem, but it appears to stem instead from the fact that the blank crossbuck was identified as a RAILROAD CROSSING sign so frequently that even though the addition of words identifying it as such increased the rate

¹⁰ Based on a chi-square test with 366 tokens in a table with five degrees of freedom. (Note that here and elsewhere responses that did not actually offer a judgment on the meaning of the sign or that simply expressed confusion were not included in the analysis.) Since the data here and elsewhere in this paper was consistently binary and discrete rather than scalar, testing for statistical significance in this study was done using chi-square tests with the threshold for statistical significance was set at the arbitrary level of $p < .05$. The Holm-Bonferroni method was used to eliminate false positives in cases where more than one test was necessary.

¹¹ Based on a chi-square test with 73 tokens in a table with one degree of freedom.

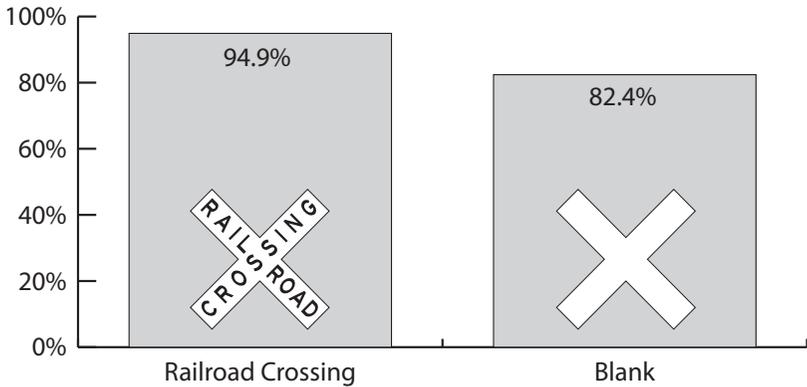


Figure 8. Rate of identification of railroad crossing signs as matching sign shape.

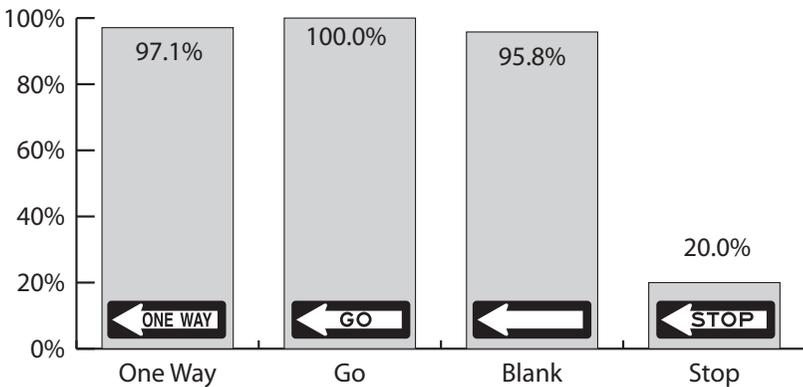


Figure 9. Rate of identification of one-way-shaped signs as matching sign shape.

of correct identification, the increase in correct identifications couldn't rise to the level of statistical significance. Therefore, this particular sign can't be used to draw conclusions about the effects of linguistic content on road signs.

The remaining signs, however, all show significant differences between at least some sorts of linguistic content. We begin with the white arrow on a black horizontal rectangle, which is consistently used for the ONE WAY sign. The results for this are shown in **Figure 9**. There is no statistical difference between the signs reading *one way* or *go*, or the blank sign—all of these were identified at very high rates as ONE WAY signs. However, the word *stop* had a significant effect blocking the identification of this as a ONE WAY sign.¹²

¹² Based on a chi-square test with 75 tokens in a table with three degrees of freedom; the non-difference between the blank sign and the ones reading *one way* and *go* was based on a chi-square test on that subset of the data.

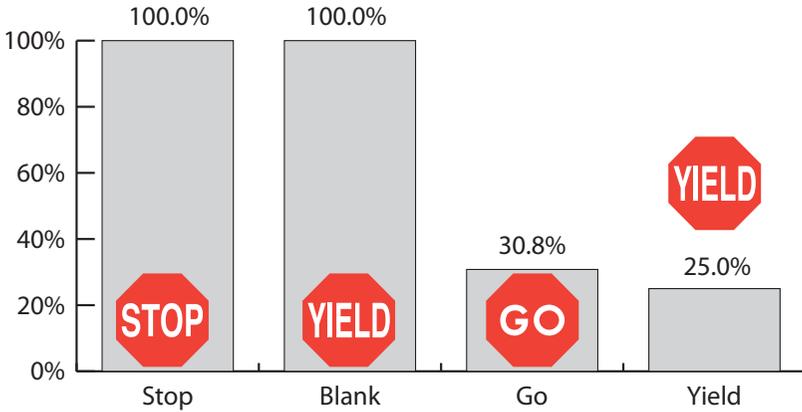


Figure 10. Rate of identification of stop-shaped signs as matching sign shape.

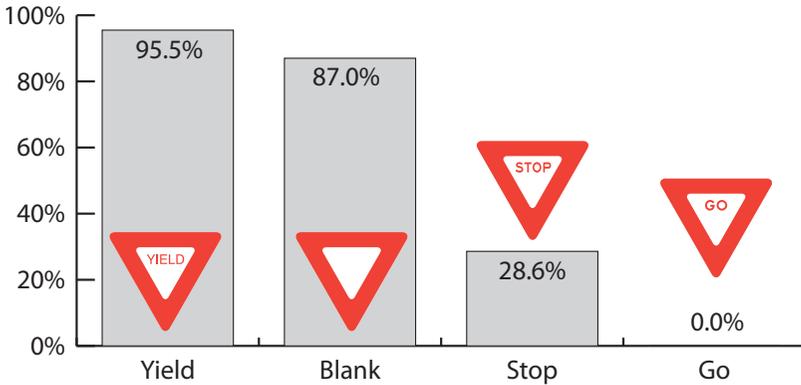


Figure 11. Rate of identification of yield-shaped signs as matching sign shape.

Results for the red octagon are shown in **Figure 10**. Similarly to the ONE WAY-shaped signs, there was no difference in identification of the blank red octagon and the red octagon reading *stop*—in fact, both of them were identified as STOP signs 100% of the time. However, text reading *go* or *yield* had a significant blocking effect on the interpretation of the red octagon as a STOP sign.¹³

Figure 11 shows the panel’s interpretation of the downward-pointing red triangle, which is consistently used for the YIELD sign. In this case, there was again no statistically significant difference in the rates of interpretation of all the blank sign and the sign reading *yield*. However, the phrases *stop* and *go* led to large significant differences in the interpretation of

¹³ Based on a chi-square test with 107 tokens in a table with three degrees of freedom. The lack of difference between the blank sign and the one reading *stop* could not be tested statistically (since there was no variation in the responses), but we still feel confident making that claim.

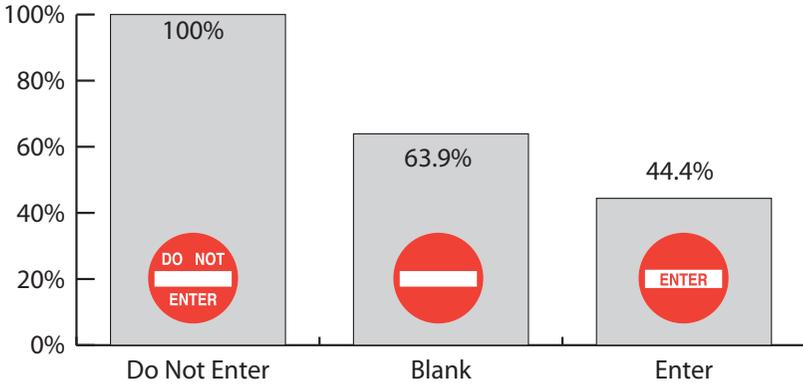


Figure 12. Rate of identification of do not enter-shaped signs as matching sign shape.

the sign shape, to the point that including the word *go* on this sign completely blocked the interpretation of this shape-color combination as a YIELD sign.¹⁴

Finally, results for interpretation of the squared red circle are shown in **Figure 12**. Even though all of the respondents identified this as a DO NOT ENTER sign when the phrase *do not enter* was included on the sign, confusion increased significantly when the phrase was left off the sign, and even more when the phrase on the sign was *enter*.¹⁵ It should be noted that, alone among the sign shapes discussed in this paper, linguistic content was necessary for the panelists to interpret this sign shape as a DO NOT ENTER sign.

5. CONCLUSIONS AND FUTURE DIRECTIONS FOR RESEARCH. After all this, the implications are clear and, at core, unsurprising: Linguistic content has an effect on interpretation of meaning. The details of this, though, are interesting.

In particular, in the case of road signs, where linguistic and nonlinguistic content are intended to reinforce each other for a variety of reasons, linguistic content reinforces the expected interpretation of nonlinguistic content, but linguistic content can also override the nonlinguistic content. This is perhaps unsurprising given the differences between processing of linguistic and nonlinguistic information discussed at the beginning of this paper, but what is surprising is how completely linguistic content can, in some cases, result in a reading that doesn't match the nonlinguistic input. Consider, for example, the downward-pointing red triangle, where the effect of the linguistic cue *go* was so strong that no panel member interpreted the resulting sign as a YIELD sign. This is, of course, not always the case; consider that the white arrow on a black horizontal rectangle was consistently interpreted as a ONE WAY sign even when the linguistic content read *go*. We intend to look at

¹⁴ Overall results based on a chi-square test with 55 tokens in a table with three degrees of freedom. (The non-difference between the blank sign and the one reading *yield* was based on a chi-square test on that subset of the data.)

¹⁵ Based on a chi-square test with 85 tokens in a table with two degrees of freedom.

this interplay between the linguistic and nonlinguistic content of such signs more closely in the future.

Of course, not all road signs act the same way with regard to interpretation of linguistic and nonlinguistic content. One particularly intriguing case is the squared red circle, which is consistently used for the DO NOT ENTER sign. This is the only sign where there was a significant difference between the interpretation of the blank version of the sign and the sign with its normally expected linguistic content. For the other signs, the blank version of each sign was interpreted at a very high rate with the meaning that its shape-color combination always has, and so the addition of standard linguistic content couldn't affect the interpretation of the sign enough to result in a significant difference. The blank squared circle, on the other hand, was only attributed the meaning associated with its shape 63.9% of the time. Interestingly, this shape-color combination (or an extremely similar one) without any linguistic content is regularly used as a DO NOT ENTER sign in other jurisdictions (including Canada, Japan, and most of Europe), and so we plan to investigate whether drivers from the United States who have had experience driving outside of the United States interpret this sign differently from those who, as the panel we report on here, have not had such experience.

Finally, we wish to mention what is probably the major shortcoming of a study of road signs made using a survey instrument: The presentation of road signs to the survey respondents was highly unnatural, particularly in that respondents were allowed as much time as they wished to offer an interpretation of the stimuli. This is, of course, not a realistic simulation of the way drivers interpret road signs—in actual practice, drivers have only seconds, often fractions of a second, to interpret road signs and behave accordingly, and the amount of time drivers have to react to signs has been found to affect their interpretation of them (Knoblauch and Pietrucha 1987). Therefore, we plan to take our findings from this study (along with other results from the survey, such as where drivers expect to see certain signs) to set up studies a larger, more comprehensive study of drivers' reactions to these signs in more realistic surroundings.¹⁶ With this information, we would be in a position to make recommendations on how to change road signs to increase public safety, whether by increasing redundant information to allow drivers to interpret signs more easily or by removing information (whether linguistic or nonlinguistic) from signs to avoid confusing drivers by overloading them with unnecessary information.

However, despite such limitations, the results presented here do show that, when individuals are presented with mostly-familiar items such as road signs, there does appear to be some difference in the perception of their linguistic and nonlinguistic components. Though the specific details await future refinement, we can say that we have found evidence that there is an asymmetry in the linguistic and nonlinguistic perception of items presented visually.

¹⁶ This would almost certainly involve the use of a driving simulator, since unpredictable reactions to signs in real-world situations could place drivers and bystanders at undue risk. Such an approach would still not give a perfect reflection of the way drivers interpret linguistic and nonlinguistic information on road signs, but it would be a closer approximation of reality than we are able to offer here.

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