

Development of Bilingual Freeway Exit Sequence Signs

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As a result of legislation the Ontario Ministry of Transportation was required to provide bilingual (English/French) signing on freeways in and around the Toronto area. A program of human factors testing was undertaken in the development of these bilingual signs. A part of this program, namely, the comprehension testing of 12 exit sign sequences, including the exit sequences in use, is described. A sample of 160 English, 101 French, 34 Chinese, and 58 Polish licensed drivers was tested. Drivers viewed a series of slides depicting the exit sequence as they would view it on the freeway and answered multiple-choice questions on the meanings of the signs. Alternatives were tested to determine whether the message exit/sortie was as effective as must exit/sortie obligatoire, if graphics alone were sufficient to designate lane directions, if the addition of French detracted from comprehension by non-French speakers, if pull-through signs showing route numbers detracted from comprehension, and if ground-mounted right lane must exit signs were required if this message was also on the overhead signs. In addition, various types of graphics showing the optional lane splitting off from the must exit lane were tested. The results of the tests were used in the selection of new freeway signing in the Toronto area.

As a result of Ontario government legislation the Ontario Ministry of Transportation (MTO) was required to provide bilingual (English/French) signing on freeways in and around the Toronto area. A program of human factors testing was undertaken in the development of these bilingual signs (1). This paper describes a part of this program, namely, the comprehension testing of exit sequence signs.

Much research has been conducted on freeway signing. This research has dealt with legibility, conspicuity, information-processing demands, and driver response (2). The research has shown that drivers can be expected to process only a few words per sign, especially if the sign is unfamiliar. Research on legibility emphasizes the need to increase character height from current standards if older drivers, drivers at night, and drivers with less than 20/20 vision are to have adequate distances at which to see and respond to signs. Studies of comprehension show that even commonly used symbols and messages may not be understood by most drivers.

LITERATURE REVIEW

There appears to have been relatively little research on bilingual traffic signs. A study done for Transport Canada (3), using both French and English unilingual and bilingual drivers, indicated the following:

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- It takes longer to read a bilingual sign than a unilingual sign, and this difference is greater for unilingual drivers. This finding applies to short and long messages.

- Placing messages in the top or the left position increases their glance legibility for drivers who understand that language. The effect is greatest for unilingual readers.

- Orientation of the two languages in the top-bottom format (compared with side by side) increases legibility for short (two- to three-word) messages but not for longer messages (five to seven words).

- Separation of the two languages with a vertical or horizontal line increases legibility, especially for longer messages and for unilingual drivers.

- The use of words common to both languages, such as *detour*, to save space leads to slightly poorer glance legibility than does the use of complete presentation in both languages, but the findings may be confounded by use of larger lettering for the pivotal word.

- When an arrow is used on a bilingual sign it is essential to provide a clear separation of the two languages and to ensure that the arrow is prominently displayed.

Rutley (4) compared the times required to read Welsh/English signs with the time to read English-only signs. Welsh names were presented in a different script (uppercase), in a different color, or with the two languages linked with a small bar to the left of each pair of names. It took the subjects 10 to 15 percent longer to read bilingual signs than the English ones, but this difference increased substantially when the Welsh message was at the top of each pair. The results showed no advantage to the use of a color or script code to differentiate the languages. In a second study, Rutley (5) found that English and Welsh subjects read the signs more quickly when their language was on the top of each pair.

PRACTICE IN OTHER COUNTRIES

With respect to bilingual signing it was found that no country systematically translates every sign. The country that does the most translation is Israel, where destination names are translated into Roman, Hebrew, and Arabic characters.

In Europe, despite the number of different languages and the frequency of international travel, there is little use of bilingual signing. The only areas where it appears to be used consistently are at toll-booths on freeways and at the customs areas at the borders.

The approach in Europe to accommodating different languages appears to be one of using symbol signs and using few word messages. Symbols are used for a great variety of signs, including lane drops, freeway services, and speed signs (number only within a red

circle). There is very limited use of bilingual signing in the United States namely, on the border between Texas and Mexico. Our contacts were unaware of any research underlying the use of these signs.

EXIT SEQUENCE SIGNING

The signs of greatest concern in this project were the exit sequence signs on freeways. The design of freeways in the Toronto area is unusual. First, sections of the freeway passing through the metropolitan Toronto area are essentially two parallel freeways, that is, express and collector lanes. Only the collector lanes exit directly to arterial roads. Drivers in the express lanes must first transfer to the collectors and then exit to arterial streets. Transfer points from the express lanes to the collectors occur approximately every three exits.

The second unusual feature of these freeways is that most exits involve a lane on the right that must be used as an exit lane, with the adjacent lane splitting into a must exit lane and a straight through lane at the exit. This is in contrast to other freeways, where a deceleration lane is added just before the exit, and only vehicles in that lane are forced to exit.

Although this design increases capacity, it creates a situation in which motorists are often confronted with the need to move out of the rightmost lane to avoid exiting. The current exit sequences warn the motorist of this by the use of white on blue (or green) ground-mounted signs saying "right lane must exit" (RLME). The driver must receive this message in time to avoid last-minute lane changes. There are two problems with this current arrangement. First, the ground-mounted signs are easily blocked from view by trucks. Second, the message is given by using colors appropriate to information signs instead of in the more conspicuous color, yellow, reserved for warning signs.

A committee made up of traffic, engineering, and human factors experts was formed to consider the alternatives. Alternatives were developed on the basis of a previous workshop, international consultation, and the available literature. The expert workshop had recommended a process of

- Elimination of superfluous signs,
- Reduction of message length,
- Use of symbols to replace text on signs, where appropriate, and
- For the remainder, simplification of the sign's message to reduce the final amount of bilingual text.

EXIT SEQUENCE ALTERNATIVES

A collector lane exit sequence (to arterial roads) consists of an overhead advance sign warning of the upcoming exit, a ground-mounted RLME sign, and an overhead sign at the exit itself. An express lane exit sequence (to the collector lanes) consists of a preadvance sign showing the distance to the transfer point leading to the next three collector exits; this is followed by a ground-mounted RLME sign, an overhead advance sign, a second ground-mounted RLME sign, and an overhead sign at the transfer point. The latter sign includes a pull-through sign with a route marker indicating that the driver is still on the freeway.

A total of five collector and five express exit sequences were developed and tested for comprehension and glance legibility. Alternatives presented the message that the right lane must exit more forcefully by using bilingual or symbol messages. Only the results of the comprehension testing will be described in detail. The goal

of the study was to determine a common design for the collectors and express lanes. Thus, all designs had to accommodate three destination names, as are required on the express advance signs.

Overhead Advance Signs

The current advance sign at locations with one optional lane and one right lane that must exit says "2 lanes" with an arrow [Figure 1 (a)]. This does not make it clear that vehicles in one of the lanes must exit. To overcome this problem the must exit and optional lanes were represented by using lane control arrows. Figures 1 and 2 show the various alternative advance signs tested for the collector and express exit sequences, respectively.

Two versions of the lane arrows were tested. One showed a split arrow with one portion going straight ahead and the other turning right in combination with an arrow turning right [Figure 1 (b)]. The other showed two right-turning arrows [Figure 1(c)]. Our concern

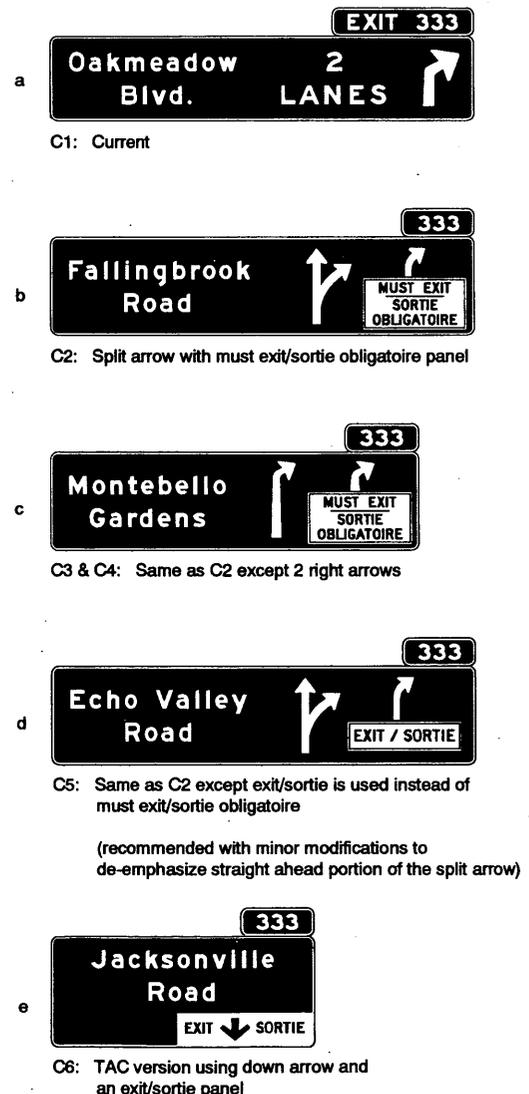


FIGURE 1 Advance signs: collector lanes.

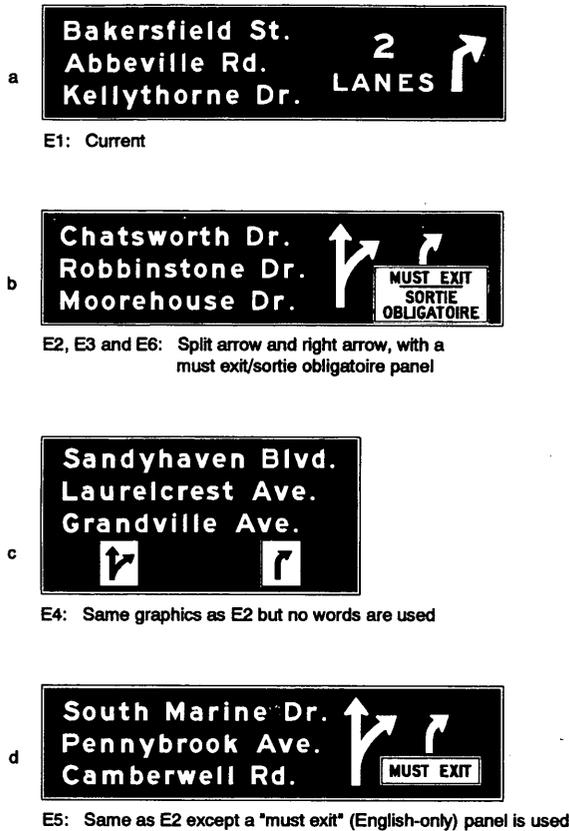


FIGURE 2 Advance signs: express lanes.

with the first version was that drivers might misinterpret the intended message about the lane splitting as an indication that there was more than one exit for the destination shown. Our concern with the second version was that drivers might assume that both lanes had to exit and move out of the optional lane unnecessarily.

We were interested in whether the words "exit" or "must exit" had to be included on the sign or whether lane arrows alone were sufficient to convey this message. Thus, one of the advance sign versions tested used lane arrows only (enclosed in a yellow panel) and no words [Figure 2 (c)]. For all alternative advance signs the words "exit/sortie" or "must exit/sortie obligatoire" were enclosed within a yellow panel. The version "exit only" used in the United States was not considered because research had shown that "must exit" is better comprehended (6).

One of the difficulties of using the phrase "must exit" is that the translation into French is very long: "sortie obligatoire" [Figure 1 (b)]. Thirty French speakers were assembled to determine whether a shorter alternative could be found. This proved unsuccessful.

Given the length of "sortie obligatoire," it was decided to test "exit/sortie" on the advance sign to determine whether this shorter version conveyed the need to exit as strongly as "must exit/sortie obligatoire" [Figure 1 (d)].

Ground-Mounted RLME Signs

The current ground-mounted RLME word sign is often attached to retaining walls close to the lane edge. Thus there was insufficient

room to increase the sign width to accommodate a bilingual message. In any case it was thought that two long messages would produce an information overload. Therefore, the only alternative considered for RLME was a symbolic sign showing the optional lane splitting into one lane straight through and one exiting lane [similar to the graphic used on the overhead advance sign in Figures 1 (b) and (d)]. This graphic is already in use on municipal roads.

Overhead Signs at the Exit

In various provinces in Canada and in the United States a yellow "must exit" panel is used on overhead signs at the exit. Because of its color this panel is conspicuous at long distances and therefore aids the driver in preparing to exit. It was decided to test the use of a yellow panel on the overhead sign at the exit. Figure 3 shows the alternatives tested for the collector lane overhead exit signs; Figure 4 shows the alternatives for the express lane overhead exit signs.

EXPERIMENTAL DESIGN

Alternatives were compared with current versions of the collector (C1) and express (E1) exit sequences and with each other. In all six collector (C1 through C6) and six express (E1 through E6) exit sequences were tested for comprehension and glance legibility. One major consideration was that the message that the right lane exited be placed above traffic on the overhead advance sign. All the alternatives considered met this requirement. Consequently, one exit sequence (E3) was tested without the ground-mounted RLME signs to see whether these signs would still be necessary. This generated four collector alternatives and five express alternatives. In addition, a collector exit sequence design (C6) being considered by the Transportation Association of Canada (TAC) was tested.

With the current exit sequence there is a pull-through sign with a route marker placed at the exit from the express lanes. On a high-density, multilane freeway the information processing demands on the driver are considerable. Therefore, we tested whether removing the pull-through sign from the express lanes would improve comprehension and glance legibility. With concerns about the impact of bilingualism on traffic safety, one alternative was tested in an English-only format and was compared with a bilingual version of the same sequence (E5).

The existing preadvance sign in the express lanes shows destinations accessed at the transfer point with the words "exit 1 km." To avoid having to translate "exit," the alternative tested used only the distance, "1 km."

The alternatives finally selected for testing allowed specific comparisons to be made relative to the issues: "must exit" versus "exit" (C2 versus C4 advance), the adequacy of graphics without words (E2 versus E4 advance), the split arrow versus two right arrows (C2 versus C3 advance), the use of the yellow panel with the words "must exit/sortie obligatoire" on the overhead exit sign versus down arrows only and no yellow panel (C2 versus C4), the impact of bilingualism (E2 versus E5 advance), the impact of ground-mounted RLME signs (E2 versus E3), and the need for a pull-through sign at the exit area on the express lanes (E2 versus E6).

EXPERIMENTAL MATERIALS

MTO uses a computer-aided design-computer-aided manufacturing (CAD-CAM) setup to produce color images of freeway signs to



FIGURE 3 Exit signs: collector lanes.

scale. These images are stored as computer files and can be printed out as color prints and inserted in other images.

For the comprehension study subjects viewed slides of the sign alternatives within the context of a freeway scene (Figure 5). By using the CAD-CAM system, sign alternatives were inserted into generated roadway images (taken from driver's view photographs). Thus, the alternatives for each sign were viewed within the same scene. False names were substituted for all destination names to prevent any bias due to subject familiarity with particular areas. All replacement names were long, representing the worst-case situation for reading the signs.

SAMPLE

The sample was stratified according to age, language, and familiarity with the freeways in question (Table 1). Three age groups were chosen: 16–39, 40–59, and 60+ years. Four language groups were tested: English, French, Chinese, and Polish. English and French subjects were recruited in Toronto (familiar subjects) and in North Bay, 450 km north of Toronto (unfamiliar subjects). Chinese and

Polish subjects were from Toronto. Subjects were required to have a valid driver's license and to drive on highways at least once per month.

Despite the intense effort that went into recruiting French-speaking subjects, we were only able to recruit 41 of the desired 60 subjects in Toronto.

Because of the multilingual nature of the Ontario population and the concern that bilingual signs might have a negative impact on drivers for whom neither English nor French was a mother tongue, two other language groups were tested. We had 58 Polish subjects and, because of difficulty in recruiting, only 34 of the intended 60 Chinese subjects.

PROCEDURE

Subjects viewed slides of roadway scenes incorporating the sign alternatives. Before viewing the slide the subject was asked a question, for example, "If you were in lane 3 would you have to exit?" The subject viewed the slide for 5 sec; this was followed by a slide with the same scene, minus the sign, simulating the situation on the

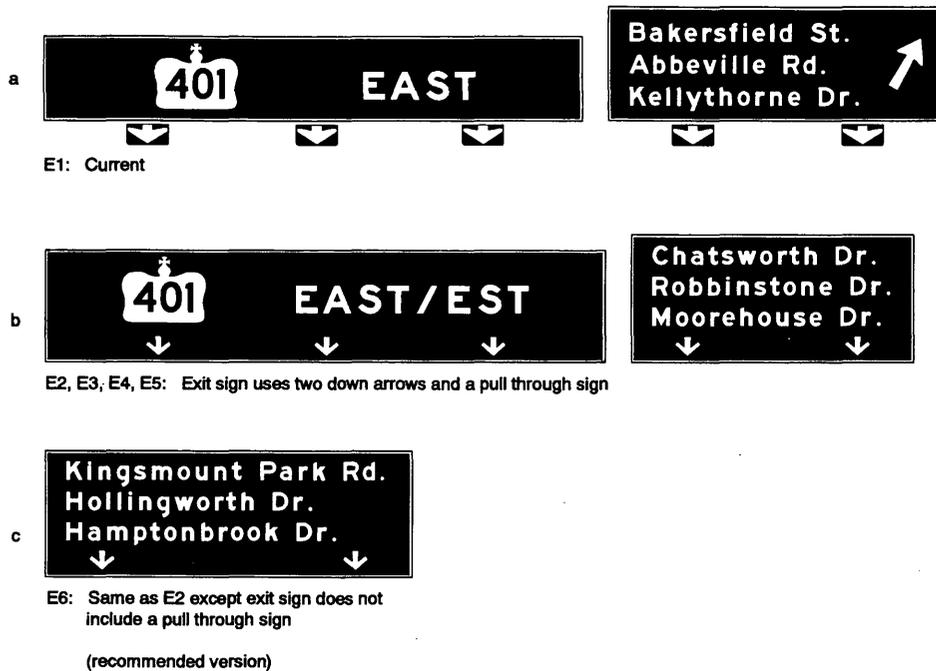


FIGURE 4 Exit signs: express lanes.

freeway of passing under a sign. The 5-sec period was chosen because it represents the maximum total time a driver is likely to look at a freeway sign. The subjects checked off an answer as they viewed the lanes-only slide. The subject indicated his or her degree of confidence in the correctness of the answer using a scale of 1 to 5.

Subjects were asked the same question for each sign in the exit sequence. For example, the question "If you were in lane 3 would you have to exit?" was answered after the subject saw the advance sign, after the subject saw the RLME sign, and again after the subject saw the sign at the exit. It was anticipated that the percent correct and the level of confidence would increase with each successive sign. All subjects practiced before data were recorded. A test session lasted approximately 20 min.

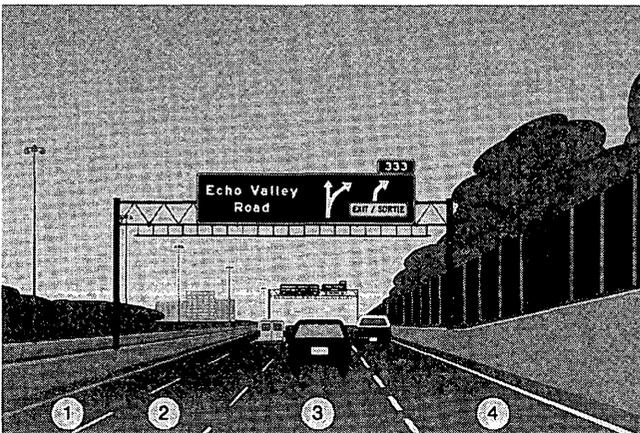


FIGURE 5 Example freeway scene in which subjects viewed sign alternatives.

Testing showed that the split arrow used in variations of the collector and express lane advance signs worked very well in conveying the optional exit nature of the one lane and the must-exit nature of the other. However, informal questioning revealed that some subjects thought there could be a second exit for the destination farther down the road. Consequently, modifications were made to the split arrow design and an additional study involving an additional 92 subjects was carried out.

Modifications involved removing the arrowhead from the straight part of the split arrow, outlining the straight part of the split arrow in white but keeping the curved part of the split arrow solid, and placing both arrows over a single lane instead of over the two lanes to which they applied. The latter was tested because of concern that it might not always be possible to position advance signs so that the arrows were directly above the lanes indicated.

RESULTS

Methods of Analysis

Comparisons of frequency data were carried out by chi-square tests (7). Comparisons between currently used signs and alternatives are presented first; this is followed by comparisons between alternatives. For all comparisons presented, data were collapsed over age, language, and location.

Collector Exit Sequences

In the collector exit sequences subjects were exposed to an overhead advance sign, a ground-mounted RLME sign, and an overhead exit sign. After each sign the subject was asked one of the following questions:

TABLE 1 Subject Samples

Age	TORONTO				NORTH BAY				Totals
	English		French		English		French		
	M	F	M	F	M	F	M	F	
18 - 39	15	11	16	14	13	13	9	7	98
40 - 59	16	12	5	6	14	13	11	10	87
60+	10	16	0	0	14	13	13	10	76
TOTALS	41	39	21	20	41	39	33	27	261
EDUCATION:	8% Grade School or less, 35% High School or Less, 57% Beyond High School								

CHINESE/POLISH STUDY
(TORONTO ONLY)

Age	Chinese		Polish		Totals
	M	F	M	F	
	18 - 39	9	15	17	
40 - 59	6	4	9	12	31
60 +	0	0	6	0	6
TOTALS	15	19	32	26	92

1. "If you were in lane 3 would you have to exit?" (answer: No)
2. "If you were in lane 4 would you have to exit?" (answer: Yes)

For each sign sequence half of the subjects were asked Question 1 and the other half were asked Question 2. Except where noted the data for these two questions have been collapsed for analytical purposes.

Current Versus Alternatives: Collector Advance

For the current collector advance sign [Figure 1 (a)] the level of comprehension was substantially lower for Question 1 (50 percent correct) than for Question 2 (90 percent correct) in comparison with that for any of the alternatives (all of which exceeded 79 percent correct for both questions). Consequently, analyses for the advance sign were carried out separately for the two questions. As can be seen from Table 2 there were significant differences ($p < .01$) between comprehension of the current advance collector sign and each of the alternatives. In each case the optional nature of Lane 3 was better conveyed through the alternative sign than through the current sign.

When responses to Question 2 for the current sign were considered and compared with those for each of the alternatives, none of the differences was found to be significant ($p > .05$). That is, comprehension that vehicles in the rightmost lane had to exit was no better with the alternatives than with the current sign design.

Current Versus Alternatives: Collector RLME

The words "right lane must exit" are used on the current RLME sign, the ground-mounted sign seen after the overhead advance sign. In all of the alternative sequences (C2 to C6) the same graphic

of two arrows was used to convey this message. To compare the current RLME with the graphic alternative, the data for the two alternative sequences with identical advance signs and RLME signs (C2 and C4) were compared with those for the current advance and RLME combination. Data for Questions 1 and 2 were combined.

For the current sequence with the word message RLME sign, 90 percent of the respondents answered the questions correctly, indicating that they knew that exit from Lane 3 was optional and that vehicles in Lane 4 had to exit. For the graphic alternative 76 percent of the subjects responded correctly. The difference was significant ($p < .01$). Thus, the RLME message was better communicated through the current word message sign than through a graphic.

*Current Versus Alternatives:**Collector Overhead Signs at Exit*

Given that the same question was asked after the subject viewed each sign, comprehension of the overhead sign at the exit depended to a considerable extent on the comprehension of the first two signs. For the exit signs the data for the two questions were combined and comparisons were made between the current signs and each of the five alternatives. At the exit comprehension of the current sequence was not significantly different from that of any of the alternatives ($p > .05$). Thus, sequences that included the yellow panel (i.e., C4, must exit/sortie obligatoire; C5 and C6, exit/sortie) on the overhead exit sign were comprehended equally as well as the current sequence. Similarly, sequences with down arrows alone (as in C2 and C3) on the exit sign were as effective as the current sequence, which uses down arrows and an up arrow on the exit sign. It must be emphasized that the results relate to comprehension of the sequence at the point at which the driver has read the overhead exit sign. We deliberately chose to look at the response to the exit sign after the other signs had been viewed instead of the response to the exit sign on its own, because this is what happens on the road. Therefore, the results cannot be used to examine the effectiveness of the various exit signs apart from the sequences in which they were used.

Comparisons Between Collector Alternatives

Comparisons of comprehension between the collector alternatives were not significantly different for advance or exit signs ($p > .05$). For the advance sign the use of a split arrow is comparable to the use of two right arrows for conveying which lanes must exit. Also for the advance sign the use of the phrase "exit/sortie" is as effective as the longer "must exit/sortie obligatoire." Including the yellow "must exit/sortie obligatoire" panel on the advance and exit signs (C4) instead of having the panel only on the advance sign (C2) did not significantly improve comprehension of the required exits.

Express Exit Sequences

In each express sequence (E1, E2, E4, E5, E6) subjects were exposed to a preadvance sign and then a RLME sign, an advance sign, a RLME sign, and an exit sign. The E3 sequence was an exception in that no RLME signs were included.

The same methods used to probe comprehension of the express sequences were used to test comprehension of the collector se-

TABLE 2 Comprehension of Collector and Express Sequences

Signs		% Correct	Chi square p
C1	Current	50	chi = 22.8, p < 0.0001
C2 & C4	Must exit/ sortie obligatoire 	88	
C1	Current	50	chi = 8.71, p < 0.005
C3	Must exit/ sortie obligatoire 	80	
C1	Current	50	chi = 20.1, p < 0.0001
C5	Exit/sortie 	93	
C1	Current	50	chi = 17.8, p < 0.0001
C6	Exit/sortie 	90	
Signs		% Correct	Chi square p
E1	Current	62	chi = 27.6, p < 0.001
E2 & E6	Must exit/ sortie obligatoire 	87	
E1	Current	62	chi = 17.9, p < 0.001
E4		89	
E1	Current	62	chi = 18.5, p < 0.001
E5	Must exit 	90	

quences. The data for the two questions were combined for the express sequence comparisons (Table 2).

Current Versus Alternatives: Express RLME

The primary concern was whether the alternative express exit sequences were comprehended as well as or better than the current express exit sequence. The configurations of all preadvance signs and RLME signs were the same for four alternatives (E2, E4, E5, E6). E3 did not include RLME signs. Therefore, E1 was compared with the combined data for the four alternatives. The correct response rate was 84 percent for the current RLME sign and 79 percent for the graphic alternative. This difference was not significant.

Current Versus Alternatives: Express Advance

For advance signs comparisons were made between E1 and E2 (combined with E3 and E6), E4, and E5. E3 and E6 differ from E2 only in the exit signs used; the preadvance, RLME, and advance signs are the same as those for E2. Comprehension was found to be poorer for the current express advance sign when compared with that for each of the three alternatives ($p < .001$).

Current Versus Alternatives: Express Exit Sign

For the express exit signs comparisons were made between the current sign (E1) and each of the five alternatives (E2, E3, E4, E5, E6). Comprehension of which lanes had to exit at the exit area ranged

from 81 to 91 percent. However, there were no significant differences in comprehension of the current sequence at the exit in comparison with that of the alternative sequences.

Comparisons Between Express Alternatives

To test whether RLME signs are needed when must exit is conveyed on the overhead sign, comparisons were made between E2 and E3 after the advance sign and after the entire sequence of signs had been seen. Neither comparison was significant. Thus, it would seem that ground-mounted RLME signs are not necessary if a must-exit panel is present on the advance sign.

Comparisons were made between E2 and E4 after the advance sign and after the entire sequence to test whether the words "must exit" are required on the advance and exit signs. Significant differences were not found. Therefore, graphics alone adequately convey the must-exit message on the advance sign.

A comparison was made between advance signs for E2 (must exit/sortie obligatoire) and E5 (must exit) to determine whether adding words in French reduces comprehension. No significant difference was found. E2 was compared with E6 (no pull-through sign) after the exit sign to determine whether the presence of a pull-through sign (E2) affected comprehension of which lanes must exit. No significant difference was found.

Comparisons between the alternatives revealed that comprehension was higher for E5 (English only) than for E4 (graphics only, no words) ($p < .05$). Comprehension of E5 was also higher than that of either E2 (must exit/sortie obligatoire) or E3 (no RLME signs). As well, comprehension of the E6 sequence (no pull-through sign) was higher than that of E4. However, these differences were marginally significant ($p < .10$).

Confidence Ratings

Drivers were asked to provide ratings of how confident they felt about each of their answers. Confidence ratings were generally very high, as were the percentages of correct responses (typically above 80 percent). No systematic relationship was found between ratings and degree of understanding for the various sign configurations.

Driver Characteristics and Comprehension

By virtue of location and selection criteria it was assumed that subjects from Toronto (local) had more experience with the current signs than the subjects from North Bay (nonlocal). The major difference found between the groups was that local drivers were far more likely to realize that the middle lane was optional when the current advance sign was used. With alternative advance signs both groups understood the signs better, and the differences between them were minimal. Comprehension following presentation of the signs at the exit was similar for local and nonlocal drivers.

To assess whether language played a role in comprehension, comparisons were made between English and French drivers. Differences between none of the comparisons proved significant. Furthermore, no significant differences were found when the responses of the Chinese and Polish drivers were compared with those of the English-speaking drivers, all from Toronto.

DISCUSSION OF RESULTS AND CONCLUSIONS

In discussing the results of the testing findings for both the collector and the express exit sequences are considered. For the sake of consistency the same design had to be recommended for both.

The current advance sign does a poor job of conveying that vehicles in the optional lane do not have to exit. This is not surprising because the message "2 lanes" with an arrow does not make the fact obvious that vehicles in one lane must exit and for those in the other it is optional. Any of the alternatives did a better job of conveying this. The difference was statistically and practically significant. Only 50 percent understood that drivers did not need to exit from the optional lane with the current sign. This level of understanding was low (64 percent) for local drivers as well as for non-local drivers (32 percent). This is in comparison with a range of 80 percent (C3) to 93 percent (C5) for correct comprehension for the alternative advance signs overall. Here differences between subjects from Toronto (94 percent) and North Bay (87 percent) were much less pronounced.

With respect to the ground-mounted RLME, a single alternative was tested, namely, a graphic RLME sign. Despite being unfamiliar to drivers in the freeway context, this graphic was well understood (79 percent correct), although it was not quite as well understood as the current word message (90 percent). However, a bilingual version of RLME would have too much information in one sign and would be too wide to fit in some locations on the freeways. Glance legibility studies (1) showed that the graphic was comparable to the current sign in terms of feature detection.

With respect to the overhead sign at the exit adding the words "exit/sortie" and a yellow panel did not improve the comprehension of which lanes exit. By the end of the exit sequence there were no differences between the current exit sequences and any of the alternatives. Comprehension was high, ranging from 80 percent for the graphic-only version (no words; E4) to 91 percent for the English-only version (must exit; E3). However, glance legibility studies (1) showed the yellow panels indicating the exit lane in the exit area would be conspicuous at very long distances, enabling drivers to be better prepared for the exit once they had associated the yellow panel with exit areas. Thus, the use of a yellow panel with down arrows on the overhead sign at the exit was recommended.

Although the alternatives were essentially equivalent in terms of comprehension, other considerations came into play to make the final selection. The C6 version was tested for TAC only and is not suitable for the express lanes for which three destination names must appear.

Glance legibility results showed that subjects had more difficulty reading the "must exit/sortie obligatoire" panel than the "exit/sortie" panel. The former was longer and in smaller print. Because the need to exit was as strongly conveyed by "exit/sortie" as by "must exit/sortie obligatoire" and the latter was more difficult to read, "exit/sortie" is recommended.

The last sign consideration related to the form of the lane control arrows. Comparing the split arrow and the right arrow with two right arrows, comprehension was higher for the former, but not significantly so. However, if the two right arrows were to be used for the optional lane situation, this raised questions about how the situation in which vehicles in both right lanes must exit would be signed so that it could be differentiated from the optional lane situation. Therefore, the advance sign recommended was C5, with the message "exit/sortie" within a yellow panel and a split arrow and right turn arrow designating the lane layouts.

As discussed earlier concerns were raised about the fact that the split arrow may mislead some drivers into thinking that one could reach the destination by going straight ahead and by going to the right. The straight-ahead portion of the arrow was deemphasized, and several versions of this advance sign were further tested. A version of C5 [Figure 1 (b)] with a deemphasized straight-ahead arrow was recommended.

This recommended design for the advance signs on the express and collector lanes cannot be said to be fully satisfactory. On the positive side, it does a much better job (90 percent comprehension) than the current sign (50 percent comprehension) in conveying that exit from one lane is optional and that vehicles in the other lane must exit. On the negative side, on seeing only the advance sign approximately one-third of the drivers thought that there might be a second exit for the destination farther down the road.

A trade-off needed to be made. First, the reasoning was that even though drivers may think there is a second exit when they see the advance sign, by the time they see the exit sign most of them should realize that this is the only exit. Second, the straight-ahead portion is perceived as applying to the optional lane even for those drivers who think there is a second destination. Therefore, drivers should be situated in the correct lane for exiting, and late lane changes should not result. It would be more dangerous to mislead drivers into thinking that both right lanes were exiting (a possibility if the two right arrows are used when exits have one optional lane and one right lane that must exit). This situation would be likely to lead to unnecessary lane changes among drivers who did not wish to exit at that destination.

As shown by the results for drivers from Toronto versus those from North Bay driver familiarity may have initially influenced comprehension on the advance signs but does not appear to have been influential in the overall comprehension after the exit signs at the exit area. None of the comparisons between language groups was found to be significant. This is not really surprising, given that non-English-speaking drivers are used to reading signs in English and that the addition of French words was minimal.

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