Motorist Understanding of and Preferences for Left-Turn Signals

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A survey of licensed drivers was conducted at the 1988 Indiana State Fair to determine motorists' understanding of and preferences for left-turn signal alternatives including permissive, protected, and both protected and permissive (p/p) signals, and leading and lagging phase sequences. Survey responses were received from a diverse but generally representative sample of over 400 people. Statistics such as the respondent error rate during the understanding portion of the survey consistently indicated that the survey data were not biased in any substantive way. Several notable results emerged from the analysis of the survey responses. The protected signal was by far the best understood, whereas the p/p was the most often misunderstood. The Left Turn Yield on Green ● sign proved more confusing than the other p/p sign conditions tested, including the no sign condition. Among signals, the protected was most often preferred, and the permissive proved the least popular. For many reasons, the leading sequence was preferred by more respondents than the lagging sequence.

A survey of licensed Indiana drivers was conducted as part of a research effort on the effects of left-turn signal alternatives in Indiana. The purpose of the survey was to determine the relative levels of understanding of and preferences for the various left-turn alternatives under consideration. The results were used with other information gathered during the research to help establish guidelines for the placement of various left-turn signal alternatives.

The following signal alternatives were included in the survey:

- The permissive scheme, under which vehicles may turn left when receiving a green ball signal and when sufficient gaps appear in the opposing traffic stream, which also has a green ball signal;
- The protected scheme, under which vehicles may turn left only when receiving a green arrow signal that affords them the exclusive right-of-way through the intersection, and
- The p/p scheme, under which protected left turns may be made at another point in the cycle.

In Indiana, the p/p scheme is accomplished most often by the use of a doghouse display with five signal lenses. Also of interest was the question of whether, for protected and p/p schemes, the green arrow phase should precede or follow (lead or lag) the green ball phase.

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Previous surveys (*1–5*; P. Basha, unpublished memo) have been conducted on the subject of left-turn treatments. However, several reasons prompted the belief that a new survey would provide more worthwhile data. First, the context of the previous surveys, including time and place, was significantly different from that of Indiana in 1988. Second, the respondents to previous surveys came from similar areas, had similar backgrounds, or were limited in number. Finally, although data on the understanding of signal alternatives were plentiful in the literature, data on preferences for different signal alternatives were sparse. Especially critical was the paucity of data on preferences for leading or lagging left-turn phases. Thus, a survey overcoming these limitations was desired.

METHODS

A survey instrument that would overcome the limitations of previous surveys, provide data relatively quickly, and remain within project budgetary restrictions was desired. After more traditional telephone and mail survey techniques had been explored and rejected because of the very complex messages to be conveyed to respondents, a personal interview format was selected. The 1988 Indiana State Fair was selected as the time and place for the interviews. The state fair provided a convenient forum in which a large, diverse sample of drivers from all parts of the state could answer questions.

The script for the interviews was pilot tested and revised many times before the state fair. The final script contained questions in three major areas: respondent demographic data (i.e., age, sex, county of residence, and number of miles driven per year), understanding of left-turn alternatives, and preferences for left-turn alternatives. For the main part of the understanding portion of the survey, each respondent viewed eight sign and signal displays and was asked to choose the correct action from among four potential left-turn actions. Table 1 presents the eight signal displays each subject viewed during the understanding portion and the four action choices presented with the displays. Table 1 also presents the definitions for correct left-turn actions, close (conservative) errors (actions that would probably not have catastrophic consequences in traffic), and gross errors (actions that would probably result in a catastrophe in traffic) from among the four choices for action for each display. Three sign conditions were tested with each of the three protected signal displays and with each of the three p/p signal displays, as shown in Figure 1. During the preferences portion of the survey, four pairs of

TABLE 1 SIGNAL DISPLAYS, ACTION CHOICES OFFERED, AND ERROR DEFINITIONS FOR THE UNDERSTANDING PORTION OF THE SURVEY

Display	Choice Number*		
	Correct	Close (Conservative) Error	Gross Error
Permissive - red ball	4	3	1,2
Permissive - green ball	2	3	1,4
Protected - green ball for through, red ball for left	4	3	1,2
Protected - green ball for through, green arrow for left	1	2	3,4
Protected - red ball for through, green arrow for left	1	2	3,4
Protected / Permissive - green ball	2	3	1,4
Protected / Permissive - green ball for through, green arrow for left	1	2	3,4
Protected / Permissive - red ball for through, green arrow for left	1	2	3,4

* 1= Turn left without stopping because you have the right-of-way.
2= Turn left without stopping unless you must wait for oncoming traffic to clear.
3= Stop. Then, turn left when oncoming traffic clears.
4= Stop. Do not turn until the signal changes to indicate you may proceed.

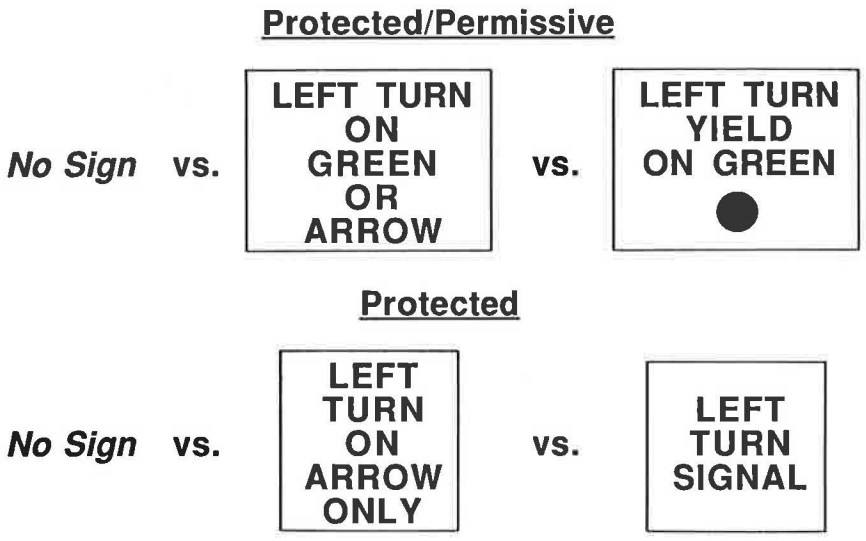

FIGURE 1 Sign conditions tested.

signal alternatives (all with no signs) were offered to the respondents, including permissive versus protected, permissive versus p/p, protected versus p/p, and leading versus lagging sequences. After viewing a pair of signal alternatives, respondents were asked which alternative they preferred and why, or whether they had no preference for either alternative. Within the understanding and preferences portions of the survey, the order in which particular displays were shown was randomized to avoid bias.

The displays shown to the respondents while questions were asked were 8.5- by 11-in. black-and-white copies of a drawing of a hypothetical intersection with the appropriate signals or

sign representing the left-turn alternative. The sample display shown in Figure 2 differs from an actual display shown during an interview only in that the active signal lenses were colored (red, yellow, or green). The design of the displays was based on the displays developed for another recent survey (5) of motorist understanding of left-turn signals. The major advantage of the displays was that they conveyed the idea of the left-turn alternative in the context of a typical intersection (a four-lane divided street with left-turn bays meeting a minor street) without distracting background noise, because the main points of the survey were understanding and preference, rather than perception. However, because the displays were static, changes in signal indication were difficult to depict. Figure 3 shows a display developed for the question on preferences for leading or lagging left turns, for which the signal sequence was the main point of the presentation.

The interviews were conducted from 9:00 a.m. to 5:00 p.m. on the first 4 days of the 1988 Indiana State Fair (Wednesday, August 17th through Saturday, August 20th). The state fairgrounds are in Indianapolis, so the fair attracts many people from that metropolitan area. However, the central location of Indianapolis and the wide variety of different exhibits attract many different types of people to the fair from all parts of the state. The interviews were conducted at a table on the second floor of the 4-H Exhibit Hall in an area devoted otherwise to arts and crafts displays and demonstrations. The location proved advantageous, because a steady number of people walked past the table. Also, no particular bias toward traffic or highways was evident in the population of passers-by (as opposed to a location near the Indiana Department of Transportation booth, for example, which might have attracted respondents particularly interested in, or unhappy about, traffic or highways). The booth was adorned with mock Stop signs and traffic signals and posters explaining the general purposes of the survey (traffic signals and safety) and the names of sponsoring organizations.

Respondents were procured in two ways. People walking by the table who took an obvious interest in the posters and signs were asked by survey personnel whether they wished to participate. Most of these people were eager to help with the survey. In addition, interviewers asked each adult passer-by to participate in the survey. This method yielded many respondents, although the nonresponse rate was high. Although statistics on nonresponse were not maintained, survey personnel estimated that about half of the people asked to participate without first expressing an interest refused to do so. The bias introduced to the survey results by these refusals was small, however, because the reasons people gave for not responding had nothing to do with the survey purpose and because the exact survey purpose (i.e., left-turn traffic signals) was not revealed until some expression of interest was shown by a potential respondent.

Respondents received three fair amusement coupons (worth $0.45 each) for completing the interview. Interviews lasted 5 to 10 min and were conducted by graduate students in the transportation engineering program in the Purdue School of Civil Engineering. The interviewers were thoroughly briefed before the survey began and were encouraged to repeat the script as closely as possible with each respondent to avoid bias between interviewers.

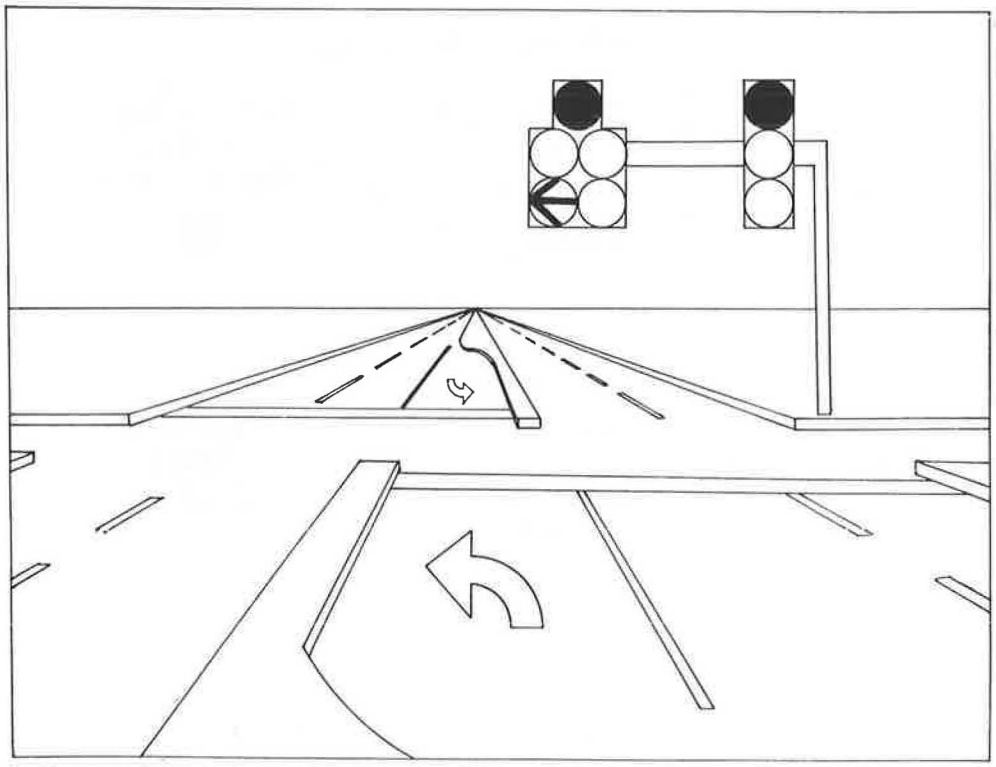

FIGURE 2 Typical survey display.

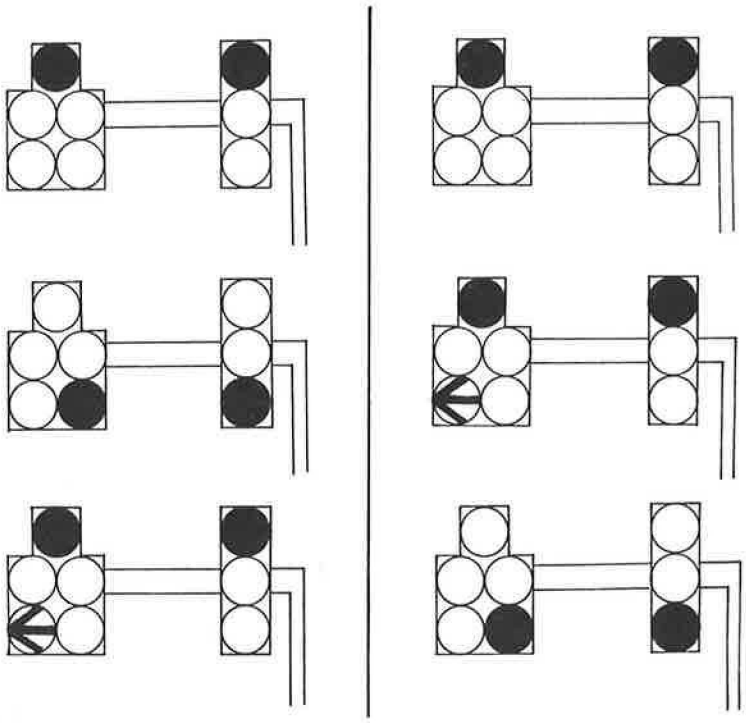

FIGURE 3 Lagging and leading sequence display.

RESULTS

After an initial warm-up period for interviewers on the first day, the survey proceeded without problems or changes. During the four survey days, 402 responses were recorded. All respondents were licensed drivers or holders of learner's permits who claimed an Indiana address.

The survey respondents were representative of the population of Indiana drivers in several ways but differed from that population in several other ways. The most significant way in which the sample was representative of Indiana drivers in general was the distribution of the respondents' residences. The breakdown of reported counties of residence revealed that responses were received from people living in 85 of the 92 counties in Indiana. The ages reported by respondents also revealed a wide distribution. Table 2, presenting the breakdown of the responses to the question on age, indicates that the most frequent response and the 50th-percentile response was for the 36- to 45-year age group and that younger and older drivers were well represented. The reported mileage driven by respondents was also representative of the general population, which was not surprising considering that the question on the subject was worded to mention the average general mileage of 10,000 mi/year. The median and mean numbers of reported annual miles driven were 10,000 and 14,000, respectively, on a range of 100 to 100,000 mi/year.

TABLE 2 RESPONDENT AGE DISTRIBUTION

Age Group, Years	Number of Responses	Percent of Total Responses	Percent of Licensed Drivers*
16-25	94	23.4	21.4
26-35	84	20.9	23.8
36-45	150	37.3	18.2
46-55	44	10.9	13.2
56-65	22	5.5	12.6
66 or over	8	2.0	10.8
Total	402	100.0	100.0

* Estimate for the year 1984 from unpublished FHWA data and Bureau of Census reports.(7)

Fifty-seven percent of survey respondents were female, whereas 49 percent of licensed drivers in Indiana (in 1984) were female (*6*).

The survey was not especially representative for the proportion of urban to rural area residents responding. Only 52 percent of the respondents were from urban counties (defined as belonging to Standard Metropolitan Statistical Areas), as opposed to the 1980 statewide population figure of 67 percent (*7*). The overabundance of rural county residents in the sample was treated by close examination of the urban or rural county of residence variable throughout subsequent analyses. Indiana is a fairly densely and evenly populated state with a wide geographical distribution of left-turn signals. Most rural counties, therefore, contain or are near towns or cities with left-turn signals, and most drivers living in rural counties regularly encounter such signals, so the overabundance of rural respondents was not considered especially critical. In sum, although the survey sample included higher proportions of female and rural drivers than the general Indiana population, the sample provided a good representation of the population for a survey gathered in one place over a limited time.

Error Rate

The quality of the responses to the survey was judged partially by an analysis of the error rate on the questions testing motorist understanding. Table 3, which presents the number of errors (i.e., incorrect responses of any type) made by the respondents on the nine questions in the understanding portion of the survey, indicates that the number of errors was well distributed. Few people entirely misunderstood the survey methodology or displays, because only one person got all nine questions wrong and only 18 people got seven or more questions wrong. Table 3 also indicates that the survey questions were not too easy, because only 43 respondents gave correct responses for all nine questions. Because most respondents made errors on a few questions, differences between displays were probably the cause of respondents' errors, as had been hoped, rather than flaws in the survey methodology.

The error rate on the nine understanding questions was analyzed with other variables to see whether patterns of errors emerged. Of special interest was the relationship between the error rate on the nine understanding questions and the particular interviewer, and between the error rate and the day the interview was conducted. Using SAS (*8*) to compute the chi-squared value as a test of the degree of association between the error rate and the particular interviewer, the significance probability (p) was found to be 0.989, indicating that the two variables were not related at the 0.05 level of significance. The chi-squared significance probability for the association between the error rate and the day of the interview was 0.954, indicating that those two variables were not closely related either. Both of these findings lend credence to the view that the quality of the survey data was high.

The error rate was also tabulated with respondent characteristics, including age, sex, annual miles driven, and urban or rural county of residence. The resulting significance probabilities were 0.356 with the age variable, 0.299 with the sex variable, 0.234 with the annual miles driven variable, and 0.079 with the urban or rural county of residence variable. None of the variables were significantly associated with the error rate at the 0.05 level, although the urban or rural county of residence variable probability was near 0.05. Table 4 indicates that urban county residents made slightly fewer errors than rural county residents. Because urban county residents were underrepresented in the survey sample, the error rate of the entire population of Indiana drivers (if they all took the survey) would probably be slightly lower than the error rate of the survey sample.

TABLE 3 DISTRIBUTION OF NUMBERS OF ERRORS ON NINE UNDERSTANDING QUESTIONS

Number of Errors	Number of Respondents	Percent of Total
0	43	10.7
1	52	12.9
2	68	16.9
3	88	21.9
4	58	14.4
5	46	11.4
6	29	7.2
7	9	2.2
8	8	2.0
9	1	0.2
Total	402	100.0

TABLE 4 DISTRIBUTION OF NUMBERS OF ERRORS ON NINE UNDERSTANDING QUESTIONS BY URBAN VERSUS RURAL COUNTIES OF RESIDENCE

Number of Errors	Urban County Respondents	Rural County Respondents	Total Respondents
0	25	18	43
1	29	23	52
2	40	28	68
3	49	39	88
4	23	35	58
5	26	20	46
6 or more	17	30	47
Total	209	193	402

Understanding and Sign Condition

The results for the understanding portion of the survey regarding signing conditions are presented in Tables 5 and 6 for the six signal displays that had variable signing conditions. The results for the protected signal displays in Table 5 indicate that no particular pattern was prevalent for the relative understanding of the no sign condition, the Left Turn on Arrow Only sign, and the Left Turn Signal sign. Even for the simultaneous green ball and green arrow display, which boasts a

TABLE 5 UNDERSTANDING OF SIGN DISPLAY ALTERNATIVES FOR A PROTECTED SIGNAL

Signal Display	Sign Display	Response Class				p-value
		Correct Responses	Close Errors	Gross Errors	Total Responses	
Green Ball for Through Traffic, Red Ball for Left Turns	No Sign	125	8	2	135	0.504*
	"Left Turn on Arrow Only"	126	5	2	133	
	"Left Turn Signal"	122	6	6	134	
	Total	373	19	10	402	
Green Ball for Through Traffic, Green Arrow for Left Turns	No Sign	97	29	9	135	0.022
	"Left Turn on Arrow Only"	97	19	17	133	
	"Left Turn Signal"	86	39	9	134	
	Total	280	87	35	402	
Red Ball for Through Traffic, Green Arrow for Left Turns	No Sign	99	24	12	135	0.173
	"Left Turn on Arrow Only"	102	14	17	133	
	"Left Turn Signal"	103	23	8	134	
	Total	304	61	37	402	

* For a chi-square analysis in which the close (conservative) error and gross error columns were combined.

TABLE 6 UNDERSTANDING OF SIGN DISPLAY ALTERNATIVES FOR A p/p SIGNAL

Signal Display	Sign Display	Response Class				p-value
		Correct Responses	Close Errors	Gross Errors	Total Responses	
Green Ball for Through Traffic and Left Turns	No Sign	54	50	30	134	0.213
	"Left Turn on Green or Arrow"	68	33	34	135	
	"Left Turn Yield on Green ●"	58	46	29	133	
	Total	180	129	93	402	
Green Ball for Through Traffic, Green Arrow for Left Turns	No Sign	88	36	10	134	< 0.0005
	"Left Turn on Green or Arrow"	93	27	15	135	
	"Left Turn Yield on Green ●"	56	47	30	133	
	Total	237	110	55	402	
Red Ball for Through Traffic, Green Arrow for Left Turns	No Sign	80	28	26	134	0.026
	"Left Turn on Green or Arrow"	92	16	27	135	
	"Left Turn Yield on Green ●"	71	37	25	133	
	Total	243	81	78	402	

chi-squared significance probability of 0.022 (indicating a significant relationship at the 0.05 level) having no sign was just slightly superior to the other sign conditions, and little distinguished the performance of the Left Turn on Arrow Only sign from the performance of the Left Turn Signal sign. From Table 6 for the p/p signal displays, a clear pattern emerges. The Left Turn Yield on Green or Arrow sign performed better than no sign and much better than the Left Turn Yield on Green ● sign. The latter sign was associated with far fewer correct answers, far more conservative errors, and far more gross errors of understanding than the other two signing conditions for p/p signals, when a green ball for through traffic and a green arrow for left turns were displayed. An analysis of the signing conditions using data only from survey respondents from urban counties revealed trends similar to those for the full data set.

Understanding of Signals

The understanding portion of the survey was analyzed using four comparisons of the relative understanding of different signal schemes. Tables 7–10 present the data and statistical test results for these four comparisons. Table 7 indicates that the permissive and p/p signal schemes, when both were displayed with green ball signals, generated almost identical numbers of correct responses. The permissive scheme, however, had a significantly greater proportion of conservative errors at the 0.05 level using the Z-test for proportions (*9*) and a correspondingly smaller number of gross errors. Table 8 indicates that the protected scheme inspired a significantly greater number of correct responses than the permissive scheme when both were displayed with red ball signals. For displays with a green left-turn arrow and green ball signals for through traffic (Table 9) and a green left-turn arrow and red ball signals for through traffic (Table 10), the protected signal scheme had significantly more correct responses, significantly fewer gross errors, and marginally fewer conservative errors than the p/p scheme. From these results, the relative levels of understanding of the signal schemes tested are clear: protected signals were the best understood, permissive signals were less well understood, and p/p signals were the least understood. The four comparisons presented in Tables 7–10 were also made using data exclusively from urban county residents, but the results were generally no different.

TABLE 7 RELATIVE UNDERSTANDING OF PERMISSIVE AND p/p SIGNALS WHEN A GREEN BALL (ONLY) IS DISPLAYED

Response Class	Signal	Number of Responses	Proportion of (402) Responses	Z Computed	Significant Difference at 0.05 Level?
Correct	Permissive	181	0.450	0.06	No
	Protected / Permissive	180	0.448		
Close (conservative) Error	Permissive	179	0.445	3.70	Yes
	Protected / Permissive	128	0.318		
Gross Error	Permissive	42	0.104	4.60	Yes
	Protected / Permissive	94	0.234		

TABLE 8 RELATIVE UNDERSTANDING OF PERMISSIVE AND PROTECTED SIGNALS WHEN A RED BALL (ONLY) IS DISPLAYED

Response Class	Signal	Number of Responses	Proportion of (402) Responses	Z Computed	Significant Difference at 0.05 Level?
Correct	Permissive	336	0.836	4.04	Yes
	Protected	373	0.928		
Close (conservative) Error	Permissive	55	0.137	4.39	Yes
	Protected	19	0.047		
Gross Error	Permissive	11	0.027	0.22	No
	Protected	10	0.025		

TABLE 9 RELATIVE UNDERSTANDING OF PROTECTED AND p/p SIGNALS WHEN A GREEN BALL FOR THROUGH TRAFFIC AND A GREEN ARROW FOR LEFT TURNS ARE DISPLAYED

Response Class	Signal	Number of Responses	Proportion of (402) Responses	Z Computed	Significant Difference at 0.05 Level?
Correct	Protected	280	0.696	3.15	Yes
	Protected / Permissive	237	0.590		
Close (conservative) Error	Protected	87	0.216	1.89	No
	Protected / Permissive	110	0.274		
Gross Error	Protected	35	0.087	2.23	Yes
	Protected / Permissive	55	0.137		

The data from the understanding portion of the survey were also examined to determine which signal phases for the protected, p/p, and permissive signals were most misunderstood. Tables 7 and 8 indicate that the green ball phase for the permissive signal was far more often misunderstood (181 correct responses) than the red ball phase (336 correct responses). Tables 8–10 indicate that the protected signal most often inspired a correct response when respondents viewed a red ball (373 correct responses), whereas the difference between the other two phases tested was not significant (the green arrow with red ball had 304 correct responses, and the green arrow with green ball had 280 correct responses). Finally, although none of the three phases of the p/p signal tested generated a high number of correct responses, the green ball phase (Table 7, 180 correct responses) was the most misunderstood. The green arrow with red ball phase of the p/p

TABLE 10 RELATIVE UNDERSTANDING OF PROTECTED AND p/p SIGNALS WHEN A RED BALL FOR THROUGH TRAFFIC AND A GREEN ARROW FOR LEFT TURNS ARE DISPLAYED

Response Class	Signal	Number of Responses	Proportion of (402) Responses	Z Computed	Significant Difference at 0.05 Level?
Correct	Protected	304	0.756	4.61	Yes
	Protected / Permissive	243	0.604		
Close (conservative) Error	Protected	61	0.152	1.85	No
	Protected / Permissive	81	0.202		
Gross Error	Protected	37	0.092	4.13	Yes
	Protected / Permissive	78	0.194		

signal (Table 10) had about the same number of correct responses as the green arrow with green ball phase (Table 9), but because the green arrow with red ball phase also had significantly more gross errors (78 to 55), this signal phase should be considered the more misunderstood of the two on the basis of these survey data.

Preferences for Signal Alternatives

A summary of survey responses to the questions on driver preferences for left-turn signals is presented in Table 11. Those data indicate that the protected signal was clearly preferred over the permissive and p/p signals, the p/p signal was preferred by more respondents than the permissive signal, and the leading signal sequence was preferred more often than the lagging sequence. For all the comparisons in Table 11, 95 percent confidence intervals on the proportion of respondents choosing one or the other signal alternative (*9*) lie outside 0.5, meaning that the differences expressed between alternatives are all significant at the 0.05 level. The preference for leading over lagging sequences was not as strong as the confidence interval would indicate, though, because almost 100 respondents had no preference.

A summary of the breakdown of preference responses, presented in Table 12, indicates that most of the preference results were unrelated to the variables examined. Age was found to be related to the preference of protected or p/p signals, with people in the 16- to 25-year group preferring a p/p signal more often. Age was related ($p = 0.054$) to preference of leading or lagging sequence, although the main contributor to the high chi-square value in this case was the tendency of younger drivers to have no preference more often. The preference for protected or p/p signals was related ($p = 0.060$) to the annual miles driven, with respondents driving the least showing greater preference for p/p signals. The annual miles driven variable was also related ($p = 0.056$) to the preference for leading or lagging signals, with the people driving the least opting for the lagging sequence or the no-preference alternatives more often. Finally, the particular interviewer

TABLE 11 PREFERENCE QUESTIONS SUMMARY

Signal Alternatives	Number of Respondents Expressing a Preference	Respondents Preferring Alternative		Confidence Interval (0.05 level)	
		Number	Proportion	Lower Limit	Upper Limit
Protected	391	382	0.977	0.962	0.992
Permissive		9	0.023	0.008	0.038
Protected	364	312	0.857	0.821	0.893
Protected / Permissive		52	0.143	0.107	0.179
Permissive	376	39	0.104	0.073	0.135
Protected / Permissive		337	0.896	0.865	0.927
Leading	307	248	0.808	0.764	0.852
Lagging		59	0.192	0.148	0.236

TABLE 12 RELATIONSHIPS BETWEEN PREFERENCES FOR SIGNAL ALTERNATIVES AND VARIOUS INDEPENDENT VARIABLES (EXPRESSED AS CHI-SQUARED SIGNIFICANCE PROPORTION)

Variable	Preference Question		
	Protected vs. Protected / Permissive*	Permissive vs. Protected / Permissive*	Leading vs. Lagging
Age	< 0.0005	0.240	0.054
Sex	0.224	0.704	0.126
Urban or Rural County of Residence	0.500	0.848	0.002
Annual Miles Driven	0.060	0.791	0.056
Interviewer	0.293	0.779	0.019
Day of Interview	0.493	0.295	0.224
Number of Errors on Nine Understanding Questions	0.140	0.394	0.526
Number of Errors on Three Understanding Questions with Protected/Permissive Signals	0.632	0.109	Not Applicable
Number of Errors on Three Understanding Questions with Protected Signals	0.268	Not Applicable	Not Applicable

* Chi-square values were calculated from tables which did not include "no preference" responses.

was found to be related to the results for the leading or lagging question. Fortunately, the trend that emerged in this relationship involved two interviewers, one who recorded a sizable number of no-preference responses and another who recorded very few no-preference responses, so the data for the leading and lagging sequences themselves did not depend on particular interviewers. The quality of the survey is reflected in the fact that the interviewer was unrelated to the results for the other questions shown in Table 12 and that the day on which a particular interview was conducted was unrelated to the results for all the preference questions.

Table 12 presents the relationship between the urban and rural county of residence variable and the preferences expressed for various signal alternatives. The preferences expressed for protected or p/p signals and the preferences expressed for permissive or p/p signals were not significantly related to county of residence. Respondents from urban counties preferred protected over p/p and p/p over permissive signals in about the same proportions as residents of rural counties. The preference expressed for leading or lagging sequence was significantly related to county of residence. Table 13 indicates that a much higher proportion of rural county residents preferred lagging to leading sequences than urban county residents. Since urban county residents were underrepresented in the respondent sample, the proportion of the total Indiana driver population that prefers leading sequences is probably higher than that reported in Table 11 for the full survey sample.

Table 12 also presents the relationship between the number of errors on the understanding questions and the preferences expressed for the various signal alternatives. The tabulated error rates were clearly unrelated to the preferences expressed. Preferences expressed by respondents who demonstrated good

TABLE 13 PREFERENCES FOR LEADING OR LAGGING SIGNAL PHASE SEQUENCES BY URBAN VERSUS RURAL COUNTY OF RESIDENCE

County of Residence	Preference			
	Leading	Lagging	No Preference	Total
Urban	140	18	51	209
Rural	108	41	44	193
Total	248	59	95	402

TABLE 14 SUMMARY OF RESPONDENTS CITING VARIOUS REASONS FOR EXPRESSED SIGNAL PREFERENCES

Preference	Reason				
	Safer	Less Delay	Less Confusion	More Like Normal	Unsure or Other
Protected	69	52	276	8	8
vs.					
Permissive	0	3	4	0	2
Protected	8	5	280	11	12
vs.					
Protected / Permissive	2	17	21	5	10
Protected / Permissive	50	59	229	13	12
vs.					
Permissive	0	2	31	1	5
Leading	61	65	27	73	39
vs.					
Lagging	11	17	11	10	11

understanding of the left-turn signal displays were very similar to preferences expressed by respondents who demonstrated poor understanding of the displays.

The reasons for preferences expressed by respondents were coded by the interviewers, and a summary of the data is presented in Table 14. Respondents overwhelmingly credited the protected signal with causing less confusion when they expressed a preference for it over both the permissive and the p/p signal. The protected signal was also preferred over the permissive signal by many respondents because it was perceived as safer and as causing less delay. Reasons given by respondents for preferring p/p over permissive signals followed a very similar pattern, with less confusion given predominantly and safer and less delay given by some. The reasons respondents gave for preferring leading over lagging sequences were well distributed, with roughly equal numbers of respondents stating that leading sequences were more like normal (i.e., more common), safer, and associated with less delay.

SUMMARY

The survey of Indiana drivers conducted at the 1988 Indiana State Fair provided usable results on the understanding of and preferences for various left-turn signal alternatives. Despite the fact that the survey was conducted in one place over a 4-day span, responses were received from a wide variety of people. The error rate computed for the understanding questions, and the lack of association between preferences expressed and particular interviewers or survey days, showed that the survey script, displays, and format were reasonable and that the data were not biased in any substantive way. However, applications of the survey data outside this project must be made carefully with the context of the survey (e.g., the tendencies of Indiana drivers and highways in 1988 and the four-lane boulevard shown in the survey displays) in mind.

Several previously cited results are particularly notable. The protected signal was by far the best understood, and the p/p signal was the least understood. The Left Turn Yield on Green ● sign proved more confusing than the other p/p signing alternatives tested, but there was little to distinguish the protected signal signing alternatives tested. The protected signal was the most preferred signal because most respondents associated it with less confusion, whereas the permissive signal was least preferred. For a wide variety of reasons, respondents expressed a greater preference for the leading over the lagging sequence.

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