



Efficacy of Traffic Signal Indicators

S.L. Mintz *

Abstract

Surveys were conducted to determine if there is a problem with motorists determining the direction indicated by traffic light signal arrows. Canadian optometrists were asked if their patients report this problem during a visual examination. Drivers were queried about difficulty with the arrows and under what circumstances the difficulties occurred. Traffic engineers were requested to comment on the use of traffic light arrows in their jurisdictions and whether or not they perceive a problem with visibility. The results indicate that many Canadians, and Manitobans in particular, reported difficulty with the arrows.

Résumé

On a effectué des sondages afin de savoir si les automobilistes éprouvent de la difficulté à déterminer la direction dans laquelle pointent les flèches des feux de circulation. On a demandé aux optométristes canadiens si leurs patients signalaient le problème au cours des examens de la vision. On a questionné les automobilistes au sujet des difficultés posées par les flèches et on leur a demandé dans quelles circonstances ces difficultés se produisaient. On a également interrogé les ingénieurs de la circulation au sujet de l'emploi des flèches sur les feux de circulation dans leur secteur et on leur a demandé si la visibilité semblait poser des problèmes. D'après les résultats, bien des Canadiens, notamment les Manitobains, ont de la difficulté avec les flèches.

Over several years of private optometric practice in Winnipeg, the author was confronted by a large number of patients who expressed complaints about difficulty which they experienced in determining the direction indicated by traffic light signal arrows. This concern was raised with the Roads and Transportation Association of Canada (RTAC) which initiated Project 129 **Efficacy of Direction-Indicating Traffic Signals**. The first step in the project was to determine, by various means, if the driving public and/or traffic engineers perceived that a problem did exist in this area, how widespread the problem was, and how serious the problem was.

At the present time only six signal lights are recognized for use in Canada.

Background

The Manual of Uniform Traffic Control Devices in Canada (MUTCDC) sets standards for (among other devices) traffic light signals in use in Canada. This manual has been formulated and approved by the Committee on Traffic Control Devices in Canada which has representation from all provincial and many municipal traffic departments. At the present time only six signal lights are recognized for use in Canada. These include the usual red, amber, and green signals in which the entire circular lens area is illuminated (known in the industry as 'ball red', 'ball amber', and 'ball green' signal lights). In addition, the MUTCDC permits the use of 'arrow green' signal lights in which a large part of the circu-

lar lens area is blacked out leaving only an arrow shape to be illuminated. ['Arrow red' and 'arrow amber' signal lights are used in some places in the United States but are not accepted as standards here.] These 'arrow green' signal lights may be oriented with the arrow-head directed up, to the right, or to the left (indicating permissive directions of travel). There is, however considerable variation across Canada in the actual dimensions of the arrow, how it is used (i.e. flashing or non-flashing), and under what circumstances it is used.

Method

The initial stage of the project consisted of a series of questionnaires designed to answer the questions raised above. A committee consisting of two optometrists and two traffic engineers met several times to design the questionnaires. A professor of psychology was consulted on the suitability of the questions asked. As a consequence of these meetings, three questionnaires were produced.

One questionnaire (Fig. 1) was to be directed at providers of vision care in Canada. The Canadian Ophthalmological Society was requested to participate but were unable to because of the lack of an official publication through which the survey could be distributed. The questionnaire was distributed to optometrists through the Canadian Journal of Optometry. The questionnaire was published twice through the years 1981-82. The optometrists were requested to mail in a postage pre-paid card which summarized the answers to the survey questions.

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Fig. 1**CAO TRAFFIC LIGHT VISIBILITY SURVEY**

As the representative of the CAO on the Roads and Transportation Association of Canada, I have undertaken a study of the visibility of arrows used in traffic lights. These traffic light arrows are available in many patterns but the most common ones indicate one direction per signal unit. These arrows may be displayed with red or amber lights or may be displayed alone. One signal light may consist of a solid red, solid amber, and solid green lights along with one or more of the following: an arrow pointing to the right; an arrow pointing to the left; an arrow pointing up (indicating straight ahead movement).

The initial phase of my study is to determine whether or not a problem exists among drivers in determining the direction indicated by the arrow(s). With this in mind, I am soliciting your assistance by answering a couple of questions below. You may, if you wish, provide further assistance by spending a four-week period keeping more precise statistics of those who present themselves with a complaint of difficulty with the traffic lights (Please do not ask patients if they have problems with the arrows; wait for them to mention the problem).

Your co-operation is much appreciated.

1. Within an average month, approximately how many patients have volunteered information that they have difficulty determining the direction indicated by traffic light arrows:
 - a. no patients
 - b. 1-5 patients
 - c. 6-10 patients
 - d. 11-15 patients
 - e. 16-20 patients
 - f. 21 or more patients
 - g. unable to answer (i.e. no arrows in community, or unaware of a problem with arrows)
2. Of those patients noted in 1. (above), approximately what percentage would you say present themselves to you with acuity of ²⁰/₄₀ or better (i.e. acuity measured as the patient is normally driving before any correction you may prescribe).
3. City, municipality, or location of your main office (i.e. where the majority of your patients are seen).
4. (Optional) Name and Address.

Please forward all replies, within 60 days, to:
Dr. Steven Mintz
212A Regent Ave. W.
WINNIPEG, Manitoba
R2C 9Z9

TRAFFIC LIGHT SURVEY

Please check the appropriate answer for Questions 1, 2, and 3. Question 4 is optional.

- | | | | |
|-------------------------|-------|----------------------------|-------|
| 1. (a) no patients | _____ | 2. (a) 0-25% | _____ |
| (b) 1-5 patients | _____ | (b) 26-50% | _____ |
| (c) 6-10 patients | _____ | (c) 51-75% | _____ |
| (d) 11-15 patients | _____ | (d) 76-100% | _____ |
| (e) 16-20 patients | _____ | (e) unable to answer | _____ |
| (f) 21 or more patients | _____ | 3. City or municipality of | |
| (g) unable to answer | _____ | main office | |

Approx. no. of patients per mo. _____

4. (Optional) Name & Address
- _____
- _____

A second questionnaire (Fig. 2) was produced in quantity and forwarded to the Department of Highways in each province and territory. Approximately 2000 were sent to Ontario and Quebec and 1000 to each other province. The Departments were requested to distribute a portion of their allocation of questionnaires to the Motor Vehicle Branch (MVB) in each major city in their jurisdiction. The Departments were encouraged to duplicate the questionnaires in greater quantities if they so desired. It was requested that all drivers who reported in person to renew their drivers licence within a specified month would be asked to fill in the questionnaire while present at the MVB office. Quebec and PEI stated that they did not wish to participate in this survey and Newfoundland and Northwest Territories did not respond in any form.

The third questionnaire (Fig. 3) took the form of a survey of traffic engineers

in the larger municipalities in Canada. This portion was undertaken by the City of Winnipeg, Streets and Traffic Division some jurisdictions being contacted by telephone and some by mail.

A higher percentage of Manitoban Optometrists reported that their patients had difficulty with arrows more frequently than did optometrists from other provinces.

Results and Conclusions

Part I: Optometrist Survey

Responses were received from 73 Optometrists distributed across Canada (Table I) representing 45 different communities (Table II) [Two respondents,

who did not indicate in which municipality or province they practiced in are not included in these tables]. Of these, only 15 reported that they had encountered patients who had mentioned a difficulty with determining the direction indicated by traffic light signal arrows (Table III). A higher percentage of Manitoban Optometrists reported that their patients had difficulty with arrows more frequently than did optometrists from other provinces.

Those optometrists who responded that their patients experienced difficulty also estimated the percentage of these patients who fell within certain visual acuity ranges (Table IV). Most significantly, it appears that a very large proportion of those who reported such difficulty had visual acuity of 20/40 or better. In other words, the majority of the patients seen by these optometrists had visual acuity as good or better than the minimum requirement for driving **and yet experienced**

Table I

Number of replies from Optometrists

| Province | B.C. | Alta | Sask | Man | Ont | Que | N.B. | N.S. | PEI | Newf |
|----------|------|------|------|------|------|------|------|------|-----|------|
| Replies | 4. | 10. | 7 | 8 | 31 | 5 | 4 | 2 | 0 | 1 |
| Problems | 0 | 1 | 1 | 6 | 5 | 1 | 1 | 0 | 0 | 0 |
| % | 0.0 | 10.0 | 14.3 | 75.0 | 16.1 | 20.0 | 25.0 | 0.0 | 0.0 | 0.0 |

Table II

Number of communities represented by reports from Optometrists

| Province | B.C. | Alta | Sask | Man | Ont | Que | N.B. | N.S. | PEI | Newf |
|----------|------|------|------|-----|-----|-----|------|------|-----|------|
| # Cities | 3 | 6 | 3 | 4 | 19 | 5 | 3 | 1 | 0 | 1 |

Table III

Patients each month reporting to optometrists difficulty with arrows

| # of Patients | None | 1-5 | 6-10 | 11-15 | 16-20 | 20 + | unable to answer |
|---------------|------|-----|------|-------|-------|------|------------------|
| # of replies | 57 | 15 | 3 | 0 | 0 | 0 | 6 |

Table IV

Visual Acuity of those reporting difficulty

| % of patients reporting difficulty who have 20/40 acuity or better | 0-25% | 26-50% | 51-75% | 76-100% | unable to answer |
|--|-------|--------|--------|---------|------------------|
| # of replies from optometrists | 4 | 0 | 6 | 8 | 0 |

Fig. 2

MOTORISTS: Traffic Engineers and Optometrists are conducting a Canada-wide driver survey. Please help us by completing this questionnaire, You need not sign it. Thank you for your cooperation.

1. Do you experience difficulty determining the direction indicated by traffic signal light arrows?
a. Yes ____ b. No ____
2. If "yes" above, when do you experience this difficulty? (Indicate more than one if necessary)
a. Day time ____ b. Night time ____ c. Dusk or dawn ____
3. Do you normally wear eyeglasses or contact lenses while driving?
a. Yes ____ b. No ____
4. Please comment, if possible, on what you feel the difficulty is with the arrows and why you have a problem determining arrow direction.

5. What city or town do you live in or spend most of your time driving in?

Table V

Driver Responses by Province

| Province | Total # Replies | Drivers reporting visibility problem | | Time of day at which arrow visibility is poorest | | |
|------------------|-----------------|--------------------------------------|---------|--|-------|-----------|
| | | Number | Percent | Day | Night | Dusk/Dawn |
| Yukon Territory | 39 | 1 | 3% | 1 | 0 | 0 |
| British Columbia | 186 | 13 | 7% | 7 | 3 | 8 |
| Alberta | 616 | 31 | 5% | 12 | 4 | 7 |
| Saskatchewan | 528 | 41 | 8% | 17 | 3 | 16 |
| Manitoba | 711 | 172 | 24% | 129 | 48 | 85 |
| Ontario | 990 | 52 | 5% | 34 | 10 | 25 |
| New Brunswick | 481 | 60 | 12% | 25 | 22 | 27 |
| Nova Scotia | 472 | 46 | 10% | 22 | 8 | 14 |
| TOTAL | 4023 | 416 | 10% | 247 | 98 | 182 |

(% reporting problems at specified time of day)

(47%)

(19%)

(34%)

Table VI

Responses of drivers (with glasses) by Province

| Province | Total # Replies | Drivers reporting arrow visibility problem | | Drivers reporting no visibility problem | |
|------------------|-----------------|--|--------------|---|---------------|
| | | No. with | % with glass | No. with | % with glass. |
| Yukon Territory | 39 | 1 | 100% | 39 | 43% |
| British Columbia | 186 | 13 | 63% | 173 | 12% |
| Alberta | 616 | 11 | 35% | 228 | 39% |
| Saskatchewan | 528 | 23 | 56% | 238 | 49% |
| Manitoba | 711 | 79 | 46% | 196 | 36% |
| Ontario | 990 | 27 | 52% | 172 | 18% |
| New Brunswick | 481 | 20 | 33% | 170 | 40% |
| Nova Scotia | 472 | 18 | 39% | 56 | 13% |

some difficulty in determining the direction indicated by the arrows.

There were not sufficient replies from the optometrists in any one community to relate these findings to those in the other surveys.

Part II: Driver Survey

A total of 4,023 responses were received from 7 provinces and 1 territory. Table V shows the provincial summary. More than 50 communities were represented in the survey and many responses were received from rural motorists. Only those municipalities from which at least 25 responses were received have been included in this portion of the study (Table VII). Of the 22 jurisdictions in this category, only 7 had a higher percentage of positive response to the question of visibility difficulty than the national average. Winnipeg led the list with 27.59%

More reported having experienced these problems in the daytime than reported problems at night or in twilight.

of the respondents replying in the affirmative to question 1, with Edmundston a distant second at 17.65%. Only three other municipalities had more than a 10% affirmative response to this question.

Applying the X^2 (Chi-squared) test shows that there is not a significant difference between the responses in Winnipeg and Edmundston. For a more accurate comparison cities of similar sizes should be used. Victoria is the city comparable in size to Winnipeg which has the highest percentage positive response. When these two cities are compared using the X^2

test, the differences are significant at the 0.001 level. When the results are compared on province-by-province basis (Table V), it is shown that there is a significant difference ($p < 0.001$) between Manitoba and New Brunswick, the two provinces with the highest percentage of positive responses.

These analyses show that there are definitely more problems experienced with traffic light arrows among the drivers in Manitoba (and perhaps to a lesser extent in Winnipeg) than in the other surveyed areas of Canada.

Another significant result was that of all those responding positively to experiencing arrow difficulty, that more reported having experienced these problems in the daytime than reported problems at night or in twilight. [Note that, in many cases, respondents indicated problems under more than one lighting condition. Also, many did not

Table VII
Driver Responses by Municipalities (with over 25 responses)

| City | Total # Replies | Drivers reporting visibility problem | | Time of day at which arrow visibility is poorest | | |
|------------------|-----------------|--------------------------------------|----------|--|-------|-----------|
| | | Number | Percent* | Day | Night | Dusk/Dawn |
| Whitehorse | 37 | 1 | 3% | 1 | 0 | 0 |
| Victoria | 112 | 11 | 10% | 5 | 1 | 6 |
| Dawson Creek | 28 | 0 | — | — | — | — |
| Edmonton | 188 | 17 | 9% | 5 | 3 | 3 |
| Calgary | 248 | 5 | 2% | 2 | 1 | 0 |
| Medicine Hat | 44 | 2 | 5% | 2 | 0 | 0 |
| Red Deer | 36 | 2 | 6% | 2 | 0 | 1 |
| Lethbridge | 34 | 0 | — | — | — | — |
| Regina | 214 | 16 | 7% | 7 | 3 | 3 |
| Saskatoon | 184 | 14 | 8% | 7 | 0 | 8 |
| Prince Albert | 65 | 2 | 3% | 1 | 0 | 0 |
| Moose Jaw | 57 | 9 | 16% | 2 | 0 | 5 |
| Winnipeg | 598 | 165 | 28% | 122 | 46 | 83 |
| Brandon | 47 | 2 | 4% | 2 | 1 | 1 |
| Ottawa | 303 | 1 | < 1% | 1 | 0 | 0 |
| Toronto (Metro.) | 202 | 5 | 2% | 3 | 2 | 4 |
| London | 39 | 3 | 8% | 1 | 1 | 0 |
| St. John | 315 | 40 | 13% | 13 | 16 | 16 |
| Edmundston | 51 | 9 | 18% | 9 | 0 | 8 |
| Bathurst | 50 | 8 | 16% | 1 | 6 | 2 |
| Campbellton | 27 | 0 | — | — | — | — |
| Halifax | 357 | 30 | 8% | 17 | 5 | 10 |

Total (22 cities) 3,236
(% reporting problems at specified time of day)
*rounded to the nearest percentage point

203 85 150
(47%) (19%) (34%)

Table VIII
Use of Traffic Signal Arrow Indications

| Jurisdiction | # of signals | # with arrows | % with arrows | Use flashing L. arrow |
|--------------|--------------|---------------|---------------|--|
| Halifax | 88 | 45 | 51% | Not at all intersec. |
| Hamilton | 294 | 8 | 2% | Not at all intersec. |
| Montreal | 1500 | 150 | 10% | Not at all intersec. |
| Ottawa | 430 | 65-108 | 15%-25% | Not at all intersec. |
| Toronto | 1450 | 50 | 3% | Not at all intersec. |
| Winnipeg | 485 | 130 | 29% | 110 intersec with Left arrow; 30 with flashing ball green. |
| Regina | 105 | 60-70 | 57%-66% | Flashing arrow if conflict-free; Flash. arrow on advanced green; Solid arrow with red = conflict |
| Saskatoon | 126 | 40-60 | 32%-48% | Flashing arrow with ball green or solid arrow alone |
| Calgary | 435 | 100 | 23% | N/A |
| Victoria | 110-120 | 20-30 | 17%-27% | Use solid arrow with amber and red; Flash. arrow with ball green |

| Jurisdiction | Flashing ball means same as solid green with flashing arrow? | Are Solid arrows, either left, right or vertical used? | Do these mean a conflict-free right-of-way? |
|--------------|--|--|---|
| Halifax | Flashing arrow is redundant | All | N/A |
| Hamilton | Yes | All | N/A |
| Montreal | N/A* | All | N/A |
| Ottawa | No: Flashing arrow never used | All | N/A |
| Toronto | No | All | N/A |
| Winnipeg | Yes | All | Yes |
| Regina | No: Flashing ball green never used | For left turn onto a one-way Street | No |
| Saskatoon | No: Flashing ball green never used | N/A | Yes |
| Calgary | No: Flashing ball green never used | At some intersections | N/A |
| Victoria | No: Flashing ball green never used | All | N/A |

*N/A means not answered

| Jurisdiction | Are arrows used when not conflict-free? | More than one arrow used on same signal | Do you feel there is problem with arrows? |
|--------------|---|---|--|
| Halifax | Yes | Yes | Yes |
| Hamilton | Yes | No: Separate signals for each direction | No |
| Montreal | No | Yes | Yes |
| Ottawa | Yes | Yes | No |
| Toronto | Yes | Yes, rarely | No |
| Winnipeg | no | Yes | Yes |
| Regina | Yes | No | Yes: suggest changing to 12" arrows |
| Saskatoon | N/A* | No | N/A |
| Calgary | N/A | N/A | Probably problem with efficiency, not safety |
| Victoria | N/A | No | Yes; inadequate signal size (8" used now) |

*N/A means not answered

Table IX
Comparison of drivers' response to engineers' response

| Jurisdiction | % use of arrows | % drivers reporting problems |
|--------------|-----------------|------------------------------|
| Halifax | 51% | 8% |
| Hamilton | 2% | — |
| Ottawa | 15-25% | 0.3% |
| Montreal | 10% | — |
| Toronto | 3% | 2% |
| Winnipeg | 29% | 28% |
| Regina | 57-66% | 7% |
| Saskatoon | 32-48% | 8% |
| Calgary | 23% | 2% |
| Victoria | 16-27% | 10% |

Fig. 3

TRAFFIC SIGNAL ARROWS QUESTIONNAIRE

1. Jurisdiction:
Name of Respondent:
Address:
2. Approximate No. of Signals:
How many intersections have arrow indications in your jurisdiction?
3. Do you use a flashing left-pointing green arrow indication?
At all intersections?
Or Only At Some Locations:
4. As far as you are concerned, do you consider the "Flashing Ball Green" exactly the same as a solid ball green with flashing left-pointing green arrow?
5. Do you use solid (non-flashing) arrow indications, either left, vertical or right-pointing?
If so, do those arrows assign exclusive, conflict-free right-of-way to drivers?
6. Do you use any arrows, flashing or otherwise, in any situation which assigns drivers right-of-way that is *not* conflict-free; that is, do you use any arrows to tell drivers "You may turn in the direction of this arrow, but watch out for motorists and/or pedestrians which may get in your way?"
7. Do you place more than one arrow indication in each signal face — and show the same "message" at all times in the left and right hand signal heads?
or
Do you provide a separate signal head(s) for left turn motorists only, with mutually exclusive red, amber, green indications?
8. Generally, do you feel that there is a problem with regards to the visibility of traffic arrow signals?

indicate a time where problems occurred.] These differences were significant at the 0.001 level. It appears that the difficulty increases directly with an increase in ambient light.

No significant correlation could be found between difficulty with the arrows and whether or not the driver normally wore corrective lenses.

Table VI shows, by provinces, the numbers and percentages of the respondents who normally wear corrective lenses. No significant correlation could be found between those that do wear glasses and those that don't as it relates to their difficulty to perceive the directionality of the arrows.

Part III: Traffic Engineers Survey

Traffic authorities in a total of 10 major cities in seven provinces responded to the survey request. The results of the survey are displayed in Table VIII. It is difficult to draw conclusions from this portion except to demonstrate the variability in how the different jurisdictions view the same traffic light situation. The

MUTCDC referred to above specifies the conditions under which the various signal indications (such as left-turn arrow) should be used. It is clear, however, that the municipalities in this survey had very different interpretations of the proper use of the same device.

When this table is compared to the results of the drivers survey (Table IX), no particular pattern becomes apparent. Winnipeg uses a lower percentage of arrow indications than Halifax, Regina and Saskatoon and higher than the other surveyed jurisdictions yet more of its drivers reported problems than in any other of the communities. Consequently, problems with the arrows can not be related solely to the frequency of the use of the arrows.

Summary

The surveys do indicate that a significant proportion of the drivers in Canada (10%) perceive a difficulty in determining the direction indicated by signal arrows. Manitobans, in particular, experience this problem to a greater extent. No determination can be made with regards

to why this problem occurs although it must be noted that there is lack of uniformity among traffic authorities *vis-a-vis* the meaning and placement of traffic light signal arrows. However, this study points out the need for further research to delineate why the problem occurs and what can be done to alleviate it. The author is currently endeavoring to do just this.

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