Turn Signals for Motor Vehicles

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An analysis of accidents in Great Britain has shown that it is important that direction signals on motor vehicles should be readily seen from the front and side as well as from the rear, particularly by cyclists and motorcyclists. In the light of this information the relative merits of present-day examples of semaphore-arm and flashing turn signals for use on cars have been compared.

It is concluded, over the wide variety of conditions tested, that a side-mounted amber flashing indicator (the "amber ear") is the most effective indicator. A rear indicator was found to become less effective the nearer it was to the stop light. There seem to be advantages in mounting signals at drivers' eye-level, and amber colored signals appear better than red or white ones.

The side-mounted indicator is likely to be of help to cyclists and motorcyclists, who are the chief victims of serious and fatal turning-car accidents at road intersections in Great Britain.

The importance of standardization in the choice of direction signals is stressed and recommendations are made regarding the choice.

● BEFORE January 1954 drivers in the United Kingdom could glance at the side of another vehicle and expect to see the driver's intention to turn indicated by one of two signals, in roughly the same position, a driver's arm or an amber semaphore arm. The semaphore arms which were used emitted a steady light of unspecified intensity, usually about 1 candela, and this appeared as the arm swung out to its operating position.

After World War II, the introduction of flashing-type direction signals in other countries inevitably led to a reconsideration of the merits of the British system. Experiments were therefore carried out by Gibbs (1) of the Medical Research Council's Applied Psychology Unit at Cambridge, England to compare the two systems for speed of response, mistakes and "attention-getting" value. The semaphore arm was found to be superior to the low-intensity flashing units then available, except when viewed in bright glare from sunlight.

In spite of these results, from January 1954 flashing direction signals were permitted in the United Kingdom as an alternative to the semaphore-arm system, partly to help the motor-vehicle export trade. The regulations, still in force, specify the minimum area of the flashers and their position relative to the axis of the vehicle. Front flashers (white or amber) may be used in conjunction with rear flashers (red or amber) and may form part of the tail light. As an alternative, flashers at the sides of the vehicle may be used. The power of a bulb in a flasher, must be between 15 and 36 watts, but no maximum or minimum light intensity is specified for any type of direction signal.

Early in 1954 two British manufacturers started fitting flashing turn indicators. These early units were of very low intensity[1] and were combined with either stop or tail lights or parking lights. This meant that a driver in Britain had to look for five possible types of turn signals in a number of positions on the vehicle, a situation that gave rise to much adverse comment culminating in a representation to the authorities to ban flashing units.

However, the quality of the flashing units was soon improved very considerably and it was thought advisable, before further changes in the regulations were made, to determine whether one of the two systems was intrinsically superior to the other and to

[1]One unit offered for sale fulfilled the legal requirements but had a light output of only 3 candelas compared with 200-300 candelas for efficient units.

see whether any of the inherent difficulties of the flashing-light system could be reduced.

TURN SIGNALS AND ACCIDENTS

The types of collisions involving serious or fatal injuries occurring at junctions have been studied in an attempt to find the numbers of accidents which would be expected to be affected by the use of clearly visible signals. The accidents selected for study were those in which a car was turning at a junction. The most frequent accident of this type is when a car is turning right[2] and is in collision with an oncoming vehicle, the next most frequent is when a car turns right from a side road, and the third most frequent is when a car turns right and is struck by an overtaking vehicle, which in two-thirds of the cases of this type of accident were motorcycles. This proportion is high partly because only serious and fatal accidents were considered and motorcyclists are more liable to get seriously hurt. These facts about accidents indicate that turn-signals should be clearly visible from the front and side as well as from the rear and should be easily seen by motorcyclists.

It was hoped, that from the beginning of 1954, as new cars came on the road fitted with flashing indicators any differences would be detectable from their changed liability to accident. However, for reasons connected with the methods used for recording accident data, this has not yet been found possible.

A series of observations were carried out to find the frequency with which direction signals are seen and the direction in which they appear to the driver of a vehicle. The following information was obtained from some 3,000 observations:

1. While driving in London the average distance away at which a direction signal was noticed was about 50 ft.
2. Half the signals were turn-right signals of approaching vehicles; there were comparatively few turn-left signals seen of vehicles proceeding in the same direction.
3. Most of the signals were seen through a small area of windscreen about 20 deg wide but with quite a small vertical range. Semaphore arms and flashers mounted on the side of the vehicle were seen horizontally or just below but flashing indicators were about 4 deg below the horizontal.

It was noticed during this survey that flashing lights on the roofs of vehicles (such as taxis) tended to be confused with traffic lights, flashing beacons and advertisement signs, whereas bottom flashers were confused with brake-lights, rearlights, reflectors and strong reflections from chromium. The semaphore arm appeared to lie in a comparatively "signal free" zone.

RELATIVE EFFECTIVENESS OF VARIOUS SIGNALS

In view of the inconclusive accident data and some considerable modifications in the type of flashing signal available, it was decided, in 1955, to re-examine experimentally the relative effectiveness of the various signal systems. There are now a wide variety of turn signals on the market, some with a light output 10 or 20 times greater than those originally tested at Cambridge and referred to above. Arrangements were made, therefore, in June 1955, to compare some of the brightest of these new flashers with the conventional semaphore arm.

The Cambridge results had, however, shown conclusively that the mounting of a stop light, flasher and rear light in the same fitting was unsatisfactory, causing confusion and giving rise to numerous errors. This conclusion is so clear-cut and a matter of everyday experience that it was considered unnecessary to repeat in any great detail experiments to demonstrate this. The following questions were therefore set down for answer:

1. (a) If rear or side flashers are arranged so as not to be confused with the stop light, are they more effective than a semaphore arm?
   (b) Is any form of front flasher more effective than a semaphore arm?

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[2]It should be remembered that vehicles keep to the left in Great Britain.

2. What is the best position to mount turn signals?

3. If two signals have the same color and intensity, which is the more effective — one that shows a flashing light or one that is steady?

The first series of experiments (Experiments 1-8) to be described answer questions 1(a) and 1(b). Test series 2 (Experiments 9-11) answers question 2 and the final question is answered by the third series of experiments (Experiments 12-17).

Experimental Method

An effective turn signal is defined as one which will command a driver's attention and at the same time be easily and therefore quickly interpreted. In the experiments to be described a number of subjects were placed in an experimental situation and the speed of their response to various turn signals was measured. In some experiments the vehicle carrying the signal was stationary, in others it was moving, but in both cases efforts were made to preserve what was judged to be the relevant essential features of a driving situation.

For the static tests, each person (called here the subject) was seated in a car and tested individually. The subject observed another car fitted with various signals and situated some distance away; in the preliminary instructions the subject's attention was directed to a continuous task. This consisted in maintaining in a horizontal position a white rectangle, the target, which was seen against a black background and placed some distance to one side of the car on which the signals were mounted (see Figs. 1 and 2). The position of the target was disturbed in an irregular manner and the

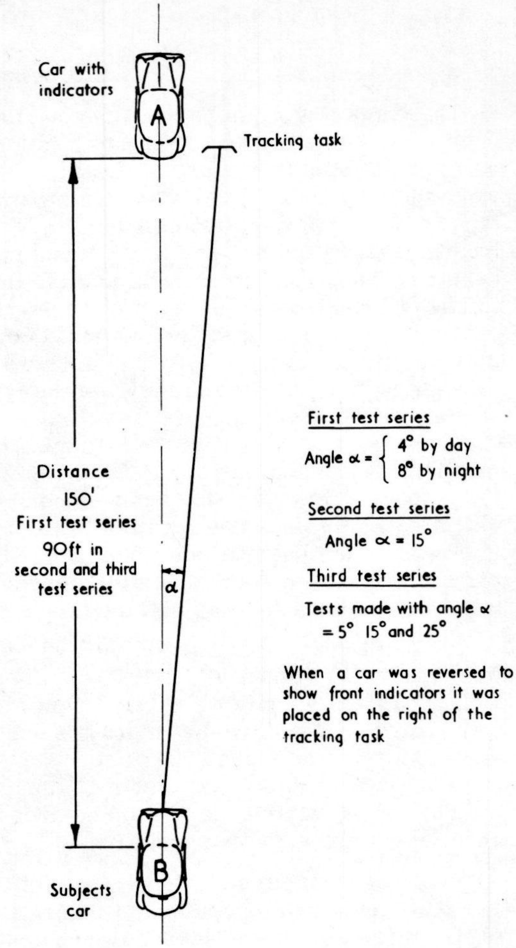

Figure 1. Plan showing the layout in the static experiments.

Figure 2. Test vehicle from front showing the levelling task to the left of the vehicle.

TABLE 1

TYPES OF SIGNAL SYSTEM AND THEIR APPROXIMATE LIGHT INTENSITIES

Turn Signal			Axial light intensity (candelas)
Standard semaphore arm			1
Red-colored flashers at rear			18
Amber-	"	" mounted on door pillar above semaphore arm (here called the "amber ear")	170
Amber-	"	" at rear (here called the "amber indicator")	240
Amber-	"	" mounted under headlamp	240
White-	"	" " " "	390

subject was enabled, by means of a remote control device, to correct this by turning the steering wheel. His attention was therefore concentrated on the levelling task, which was quite difficult, but at the same time he was required to respond to a signal on the test vehicle which was in a direction different from the one in which he was looking. Response to a signal consisted in pressing a conveniently situated lever in one of two direction, corresponding to whether "left" or "right" was indicated. The correct response switched off the signal. Subjects were instructed to extinguish each signal as it appeared as quickly as possible and were further told that their time to respond would be measured. The average response times to each signal has been used as a measure of signal effectiveness; the smaller the response time, the more effective the signal. If the response time was large, it was deduced that there were perceptual difficultires or else that the observer was forced to make a complex decision; if it was small, the signal was regarded as easily seen and easily interpreted. The differences in the scores obtained, although small, were usually real and not chance differences. Although under test conditions these differences are small, under road conditions the response times will probably increase until, when a driver is hard pressed, he may see those signals found best under test conditions but may fail to see the others. Some justification for this will be found in the results which will be given, for where there are gross differences in the ease of seeing, such as between indicators situated near to and those far from glaring headlights, the response times are significantly different in the way expected from common experience (see Fig. 4), although the absolute differences are relatively small.[3]

TABLE 2

TURN SIGNALS SEEN FROM THE FRONT OF A CAR, RANKED IN ORDER OF EFFECTIVENESS

Type of Signal	Conditions of Test		
	Day	Night	
		Undipped	Dipped
Semaphore arm	1[a]	2[a]	4
Amber ear (flashing)	1[a]	1	1
Amber indicator (flashing)	4	2[a]	2
White indicator (flashing)	3	4	3
Number of subjects	10	6	6

[a]Results such as two firsts mean either that the effectiveness scores were the same or so close that chance variations would account for the difference. Each test is based on 120 responses by each subject.

[3]In general, it has been found that the response time to a stimulus varies approximately with the inverse of the logarithm of the physical measure of the intensity of the stimulus and also depends upon the complexity of the total task over a wide range of stimuli and conditions. A survey of some of the relevant experiments will be found in (2).

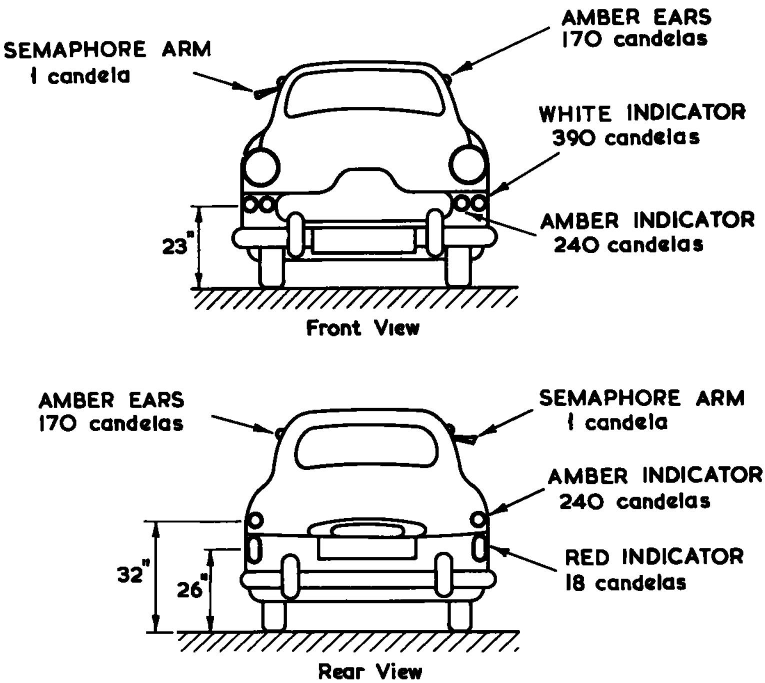

Figure 3. Diagram showing position and maximum intensities of direction signals. The signals were all additional fittings: the vehicle's own signals were not used.

Static Tests (Experiments 1 to 7)

Using the method described above, a comparison was made of the five types of signal, details of which are given in Table 1.

The positions of these signals on the experimental vehicle are shown in Figure 3. All types are in common use in the United Kingdom, the "amber ear" being frequently seen mounted on the roogs of London taxis. A plan of the experimental arrangement is shown in Figure 1. No vehicle stop light was in use in this series of tests.

These experiments were carried out in a variety of conditions, on sunny days and dull days, with the front of the observed car visible, with the rear visible, by night as well as by day. The results are given in Tables 2 and 3 in the form of a ranking of effectiveness of each type of signal under each condition tested. The numerical values on which these are based are illustrated in Figure 4.

Two further experiments (6 and 7) were carried out in the daytime with twenty subjects. In these, the subjects simply waited for and responded to the signals as fast as possible, i.e., the distracting task was not used. The variations in the speed of interpreting the direction indicated was thus found, and it was shown that the rank

TABLE 3

TURN SIGNALS SEEN FROM THE REAR OF A CAR, RANKED IN ORDER OF EFFECTIVENESS (NO STOP LIGHT IN USE)

Type of Signal	Conditions of Test	
	Day	Night
Semaphore arm	1[a]	4
Amber ear (flashing)	1[a]	1[a]
Amber indicator (flashing)	3	1[a]
Red indicator (flashing)	4	3
Number of subjects	10	6

[a]Results such as two firsts mean either that the effectiveness scores were the same or so close that chance variations would account for the difference. Each test is based on 120 responses by each subject.

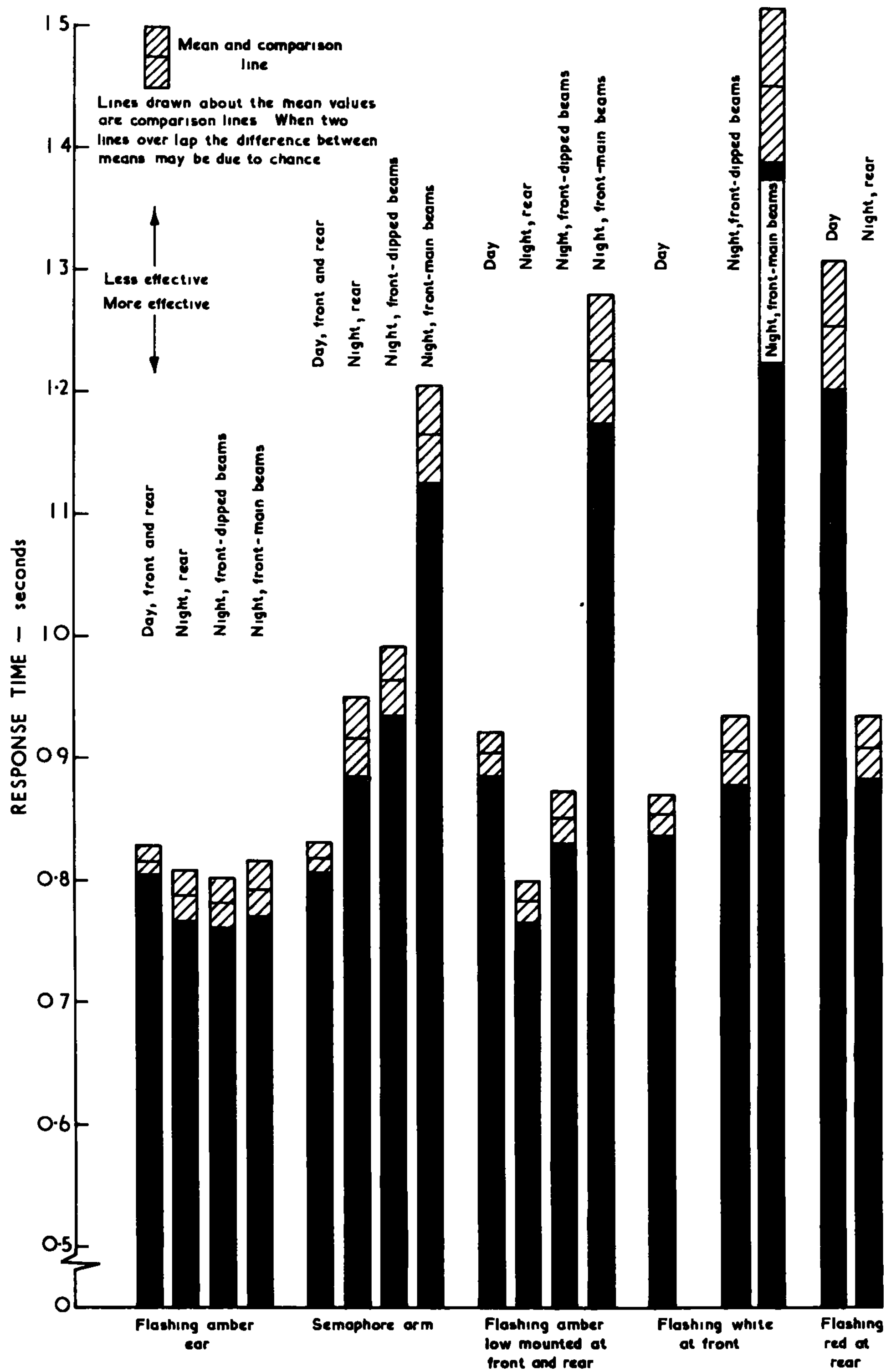

Figure 4. Response times to indicators: attention drawing under four conditions of background illumination (stop lights and side lights not used).

order of types of indicators was substantially the same as that found when the attention was directed away from the indicators. Thus, an indicator which is most easily interpreted seems likely also to be the best to attract attention.

Road Tests (Experiment 8)

These tests were carried out in the daytime to check whether the results from static tests could be generalized and applied to moving-vehicle tests. Moving-vehicle tests are more difficult to carry out and, owing to the large number of irrelevant factors which affect the performance of the task, the results tend to be very much less clear cut than those of the static tests.

Each subject was asked to drive a car about 20 to 25 yards behind a car fitted with the types of signal described. When the leading vehicle signalled a turn, the observer was instructed to do likewise and then follow the leading vehicle into the turn. Sixteen observers were used; the course followed took the vehicle through town, residential and country roads, and during the journey 29 left and 32 right (signalled) turns were made. In these experiments the stop light, which was in the same housing as the red indicator, was in normal use.

The initiation of a signal by the leading driver was recorded in his vehicle on a moving paper record. The instant the subject made his response it was relayed by radio link to the recorder in the leading vehicle, and response times could thus be measured directly from the chart. The results obtained in this experiment were insufficient to say with confidence which of the three indicators, low-mounted amber, amber ears, or semaphore-arms was most effective; it was clear, however, that the red flashers were least effective. In general, therefore, the moving tests tend to confirm the general pattern of results obtained in the static tests.

POSITION OF SIGNALS

Direction signals are at present arranged in vehicles in positions convenient to the manufacturer or pleasing to the stylist. This practice does not necessarily give the optimum position for ease of seeing and it has led to the present situation in Britain where a driver has to scan a vehicle from roof level to bumper level in order to be certain to see an indicator. Several experiments have therefore been carried out to decide which of a number of possible positions of front and rear signals is best. All the units used in these experiments were of one type, the 240-candelas amber indicator, arranged so as to give a steady signal or a flashing signal as required.

The most effective position of a signal in the test situation may, to some extent, depend on the height at which the distracting task is set. Some simple experiments showed that when driving on a level road a driver is chiefly interested in objects lying in a zone roughly 1½ deg above horizontal, to 3½ deg below, the most important zone lying between ±1½ deg from the horizontal. The distracting task was accordingly set about 1 deg below horizontal so that the subjects' eyes were directed in roughly the same direction as in a road situation.

As Seen from the Rear (Experiment 9)

Amber indicators were mounted at three different heights, 3, 9 and 18 in., center to center, above the stop light. Static tests were carried out by day and by night using each signal and switching on the stop light from time to time to simulate conditions as seen from the rear. The subject responded to the indicators as before and to the stop light by pressing the foot brake. The arrangement of the indicator, and the results, are shown in Figure 5. It will be seen that as the indicator is moved nearer to the stop light there is a decrease in effectiveness; when the separation was less than 9 in. the decrease in efficiency was very marked.

As Seen from the Front (Experiments 10 and 11)

At night the front turn-signal may have to be perceived against the glare from a headlamp. In practice conditions are even more difficult because the front indicator is often combined with a side light; this arrangement is clearly unsatisfactory and was not

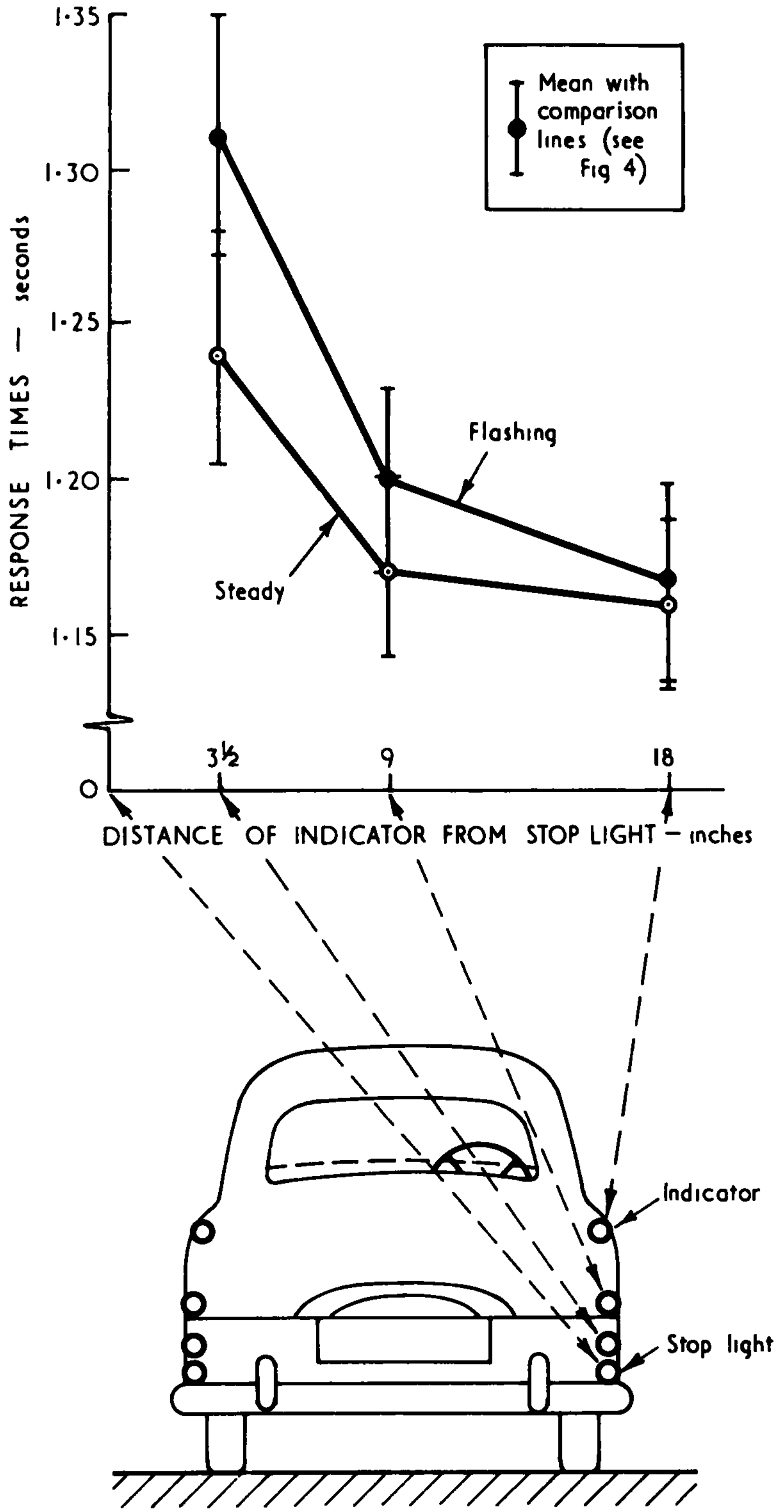

Figure 5. Response times to identical turn-signals mounted various distances from stop lights. Average of day and night results (18 subjects).

studied. The effect of arranging indicators to left and right of the headlamp and also below and above was investigated. In experiment 10, four amber indicators were arranged at equal distances of 9 in. from each headlamp, one above and one below it. The arrangerangement and results are shown in Figure 6. No differences were found in this experiment for signals above and below, but signal units outside the headlamps were better than those between them.

In experiment 11, four signals were arranged above and below the headlamp. The arrangement and results are shown in Figure 7. The signal mounted at semaphore-arm level was found to be more effective than signals above or below this position.

As Seen by Cyclists and Motorcyclists

The accident figures (Appendix A) show that, in roughly 50 percent of serious and

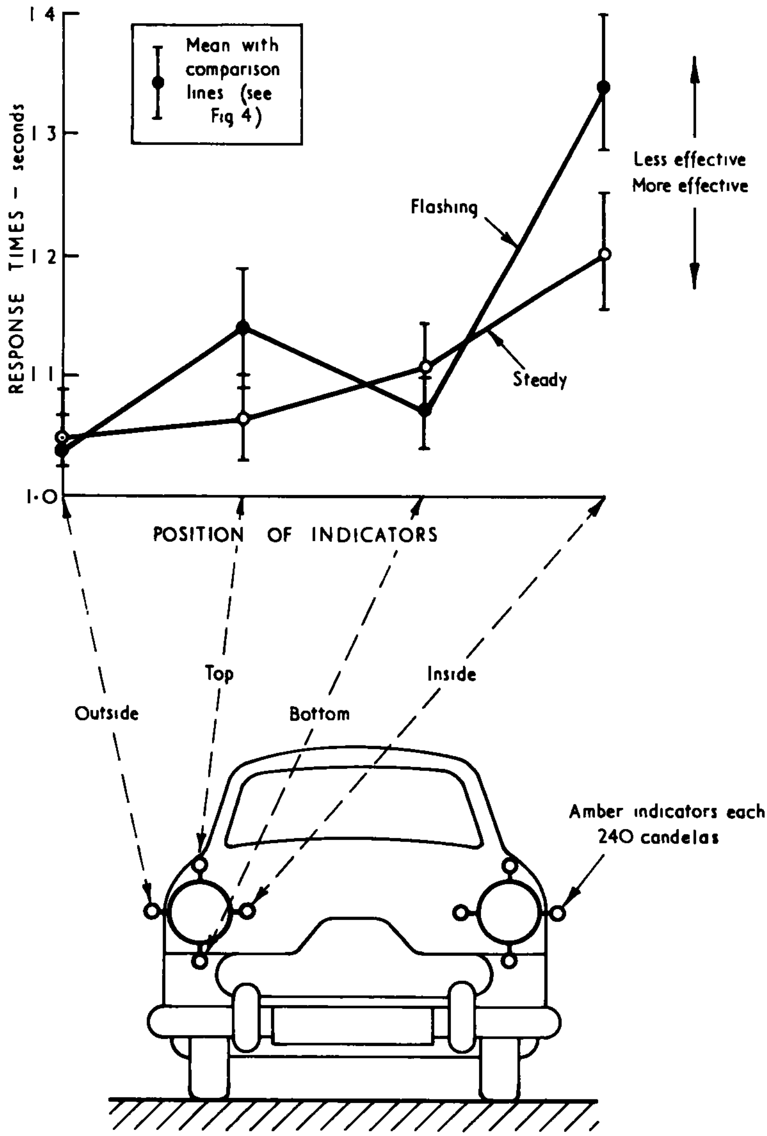

Figure 6. Response times and position of front turn signal. Four positions each 9 in. from center of lamp: night tests with headlamps dipped (9 subjects).

fatal accidents to a car turning at an intersection, the colliding vehicle was a motorcycle or a pedal cycle, either overtaking or colliding head on. It may be asked, "Which indicator is likely to be most readily seen by a motorcyclist, an amber ear or a low-mounted amber indicator?" Some simple geometrical considerations may assist in finding an answer.

If the average position of a motorcyclist's eyes when riding is assumed to be directed in a zone +1½ deg to -3½ deg relative to the horizontal in a similar way to the eyes of a car driver, Figure 8 shows the angle below the horizontal to which a motorcyclist must lower his eyes to see the amber ear and the low-mounted amber. The motorcyclist is supposed to be of average height and to be overtaking (or meeting) a car and passing it five feet from the side. It will be seen that the amber ear is always in the

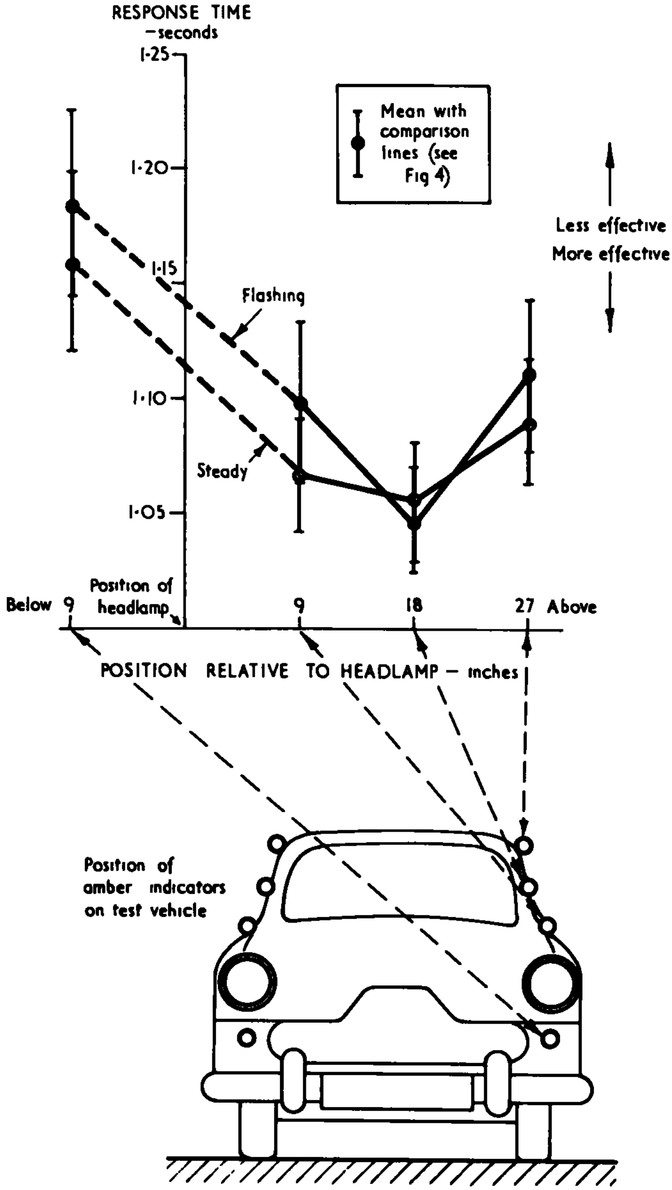

Figure 7. Effect (at night) of placing a turn signal at various heights above and below a headlamp (10 subjects).

horizontal plane, that is, it remains at eye-level but in order to see the low-mounted amber indicator the rider has to depress his eyes from the horizontal, and at distances less than 30 ft from the vehicle it is outside the normal field of view.

In busy urban traffic, distances between following vehicles are less than this. It is true that this advantage of the amber ear may be partly compensated by the higher intensity of the low-mounted amber indicator, but, near to the car on this count too, the amber ear is superior (Fig. 8).

Similar geometrical considerations apply to following motor vehicles; the difference is accentuated in the case of cyclists who have a high eye level. Cyclists and motorcyclists are frequently killed or injured when they are riding parallel with a car which turns left (see item 5 in the table in Appendix A). Figure 8 shows that the amber ear emits about 15 candelas at right angles to the side of the vehicle and would thus be of assistance to riders level with the vehicle. In this position front and rear indicators cannot be seen.

It is concluded that from the point of view of cyclist and motorcyclist the position occupied by the amber-ear indicator on the side of the vehicle is best because it is

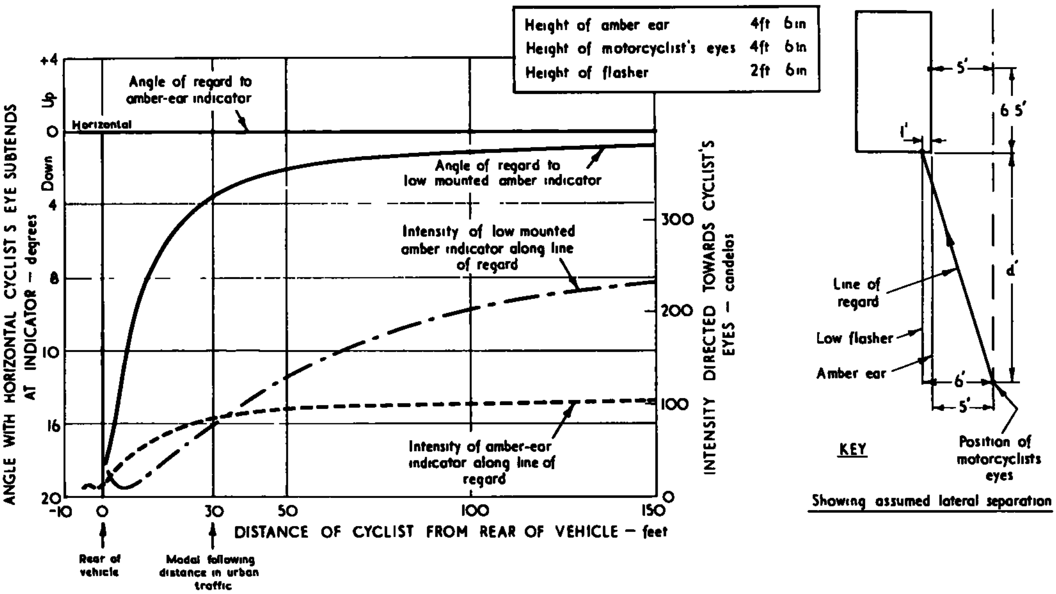

Figure 8. Visibility to the motor cyclist of low and high mounted signals. Variations in intensity and angle of regard for various distances from the vehicle.

nearer to the rider's line of vision and is easier to see when the cyclist is close to the vehicle.

FLASHING VERSUS STEADY SIGNALS

(Experiments 12 to 17)

Although the best flashing signals are more effective than the semaphore arm at night they are so much brighter that it cannot be said that the effectiveness is necessarily due to the flashing. Would the amber ear be equally effective if it emitted a steady light of the same brightness? Both static and moving vehicle experiments have been carried out to test this point.

Three conditions of background were considered: (a) conditions such as might occur on the open road when indicator lights on one vehicle are the only lights visible to a driver; (b) conditions such as might occur in an urban area where there are a number of steady lights in the field of view; (c) conditions such as will occur in urban areas when many vehicles have flashing lights and the relevant one has to be picked out. The distracting lights were arranged on either side of the test vehicle, which was itself placed at 5 deg to the line of sight to the levelling task. This angle was increased to 15 and 25 deg at other times.

The test vehicle had four turn signals; two of them amber ears and two amber indicators, and all four could be arranged to give either a steady signal or to flash 120 times a minute.[4]

Static Tests

By day the test vehicle was viewed from the rear but no stop lights were used; by night the vehicle was viewed from the front. Summarized results are given in Table 4 and in more detail in Appendix B.

At night when seen from the front in the glare of dipped headlamps the flashing indicators were, on the whole, best. By day, there was no consistent difference between steady and flashing indicators.

Road Tests

In addition to these static tests a further series of road experiments were carried

TABLE 4

STEADY VERSUS FLASHING DIRECTION SIGNALS OF THE SAME INTENSITY: STATIC TESTS: VEHICLE VIEWED FROM FRONT

Condition of test:		Most effective signal from:	
Day or night	Background	Amber-ear indicators	Low-mounted amber indicators
DAY (Rear of car in view)	Neutral (no lights)	No difference[a]	No difference
	Flashing lights	" "	" "
	Steady lights	Flashing	" "
NIGHT (Front of car in view)	Flashing lights	Flashing	No difference
	Steady lights	"	Flashing

[a]"No difference" means that differences were so small that they could be due to chance variations.

out in daylight to compare steady and flashing low-mounted amber indicators with amber ears; detailed results are given in Appendix B. In these tests, there appeared to be an advantage in using the steady lights, but this may have been due to chance variations.

A similar slight advantage was found in the daytime static tests but this also was within the limits of chance variation. A small non-significant difference in favor of steady signals was also observed in most of the experiments to determine the best position of the indicator (Figs. 5, 6, and 7). In each case the flashing condition improved more rapidly than the steady one, until at the best indicator position the two conditions were almost indistinguishable, the flashing condition being perhaps slightly better.

Summarizing, there is very little difference between the effectiveness of steady direction signals and signals flashing at 120 per min. For practical purposes they may be regarded as equally effective; such differences as there are appear to depend on the background against which the indicators are viewed and upon the personal characteristics of the subjects tested.

[4]A flash rate of 120 per min has been shown by others (3) to be more effective than rates of 60 flashes per min. The legal limits of rate of flash for motor vehicles are between 60 and 120 per min but most indicators on vehicles have frequencies at the lower end of the range.

DISCUSSION OF RESULTS

Indicator effectiveness has been shown to depend on color, position, and light intensity. The amber ear and the low-mounted amber indicator are better than the white indicator under adverse conditions. It is, therefore, an advantage for an indicator to show an amber light.

The experiments on the position of turn signals showed that the signal should be sited as near as possible to the normal line of sight and away from headlights and stop lights which are sources of interference.

In the static experiments the levelling task was arranged slightly below the driver's eye level. This was done in order to keep the subject's attention in roughly the same level as would occur during driving. It may be argued that this is the reason why eye-level indicators were found to be better but this cannot be the complete explanation as the results of the tests when no levelling task was used (Experiments 6 and 7) also gave the same result.

There are several other factors in a road situation which may favor signals at semaphore-arm level and these factors were also present in the experimental arrangements. For example, it may be that long usage has led drivers to expect signals at semaphore-arm level. In bright sunny weather subjects often reported difficulty in seeing low-mounted signals because of interference from the high intensity reflections of the sun on the chromium of the bumpers: this is illustrated in Figure 9 which is a photograph of a vehicle with a moderate amount of chromium taken in bright sunlight. The picture has been overprinted photographically to show the very bright reflections on the bumper; calculation showed that the brightest of these was about 5,000 candelas. When the car is in motion, the position of these highlights will form a changing pattern against which a driver is expected to see a flashing light of a few hundred candelas. Signals mounted on the side of the car are visible against the distant road scene which is usually darker and therefore a more effective background.

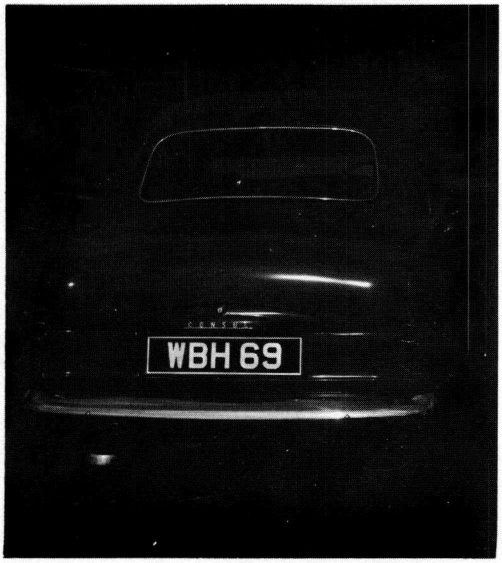

Figure 9. Rear view of a car with a moderate amount of chromium, taken in sunlight but printed so as to show several high lights. The distorted image of the sun at the right of the bumper has an intensity of the order of 5,000 candelas several hundred times greater than the adjacent flasher. The good background conditions higher on the vehicle will be noted.

One problem which has not been investigated is the reported annoyance produced by "winking lights". There is much clinical evidence that flashing lights of high intensity can precipitate epileptiform seizures[5] in some people (4) (5) (6). Frequencies as low as 3 per second can produce such effects in very young children (7) but higher rates 8 to 10 per second are generally required to produce seizures in adults. Flashing signals may have a maximum frequency of 2 a second, but a number of vehicles in a row could conceivably produce a combined frequency two or three times this. The intensity for direction signals is probably far too low to have any serious effect, although it is a question which in Great Britain might well be referred to the Medical Research Council for comment. The fact that some people are disturbed and irritated by flashing lights

[5]Such seizures, the symptoms of a variety of disturbances, may vary in form from a momentary twitch or inattention to a "grand mal" convulsion.

in a way which might lower their driving efficiency may well be a very mild manifestation of the phenomenon.

There are several factors concerning the relative merits of steady and flashing lights which either have not been investigated or which cannot be effectively assessed experimentally. Amongst these factors are the importance of the distraction from the task of driving caused by many flashing lights seen at the same time, the attention-drawing quality of a signal seen for the first time in operation (i.e. when the actual switching on is not observed due to the presence of another vehicle), and the importance of the time-lag in the operation of the flasher unit. This lag is due to a defect in the design of the units which, in effect, start their cycle of "on-off" periods with an "off". Although flashers can be made with very small delays, common types in use have an operating delay of up to one second before the first flash appears. Semaphore-arm signals, on the other hand, take only about one-quarter of a second to reach this final position.

The experiments which have been described were concerned with human response to a signal once it had appeared; mechanical delays in flasher units were therefore neglected because, for the purposes of the experiment, they were irrelevant. However, in an actual road situation some account must be taken of this lag of possibly a second's duration. In most cases a driver operates his indicator some time before he intends to turn and the fact that the signal does not show immediately may be of little importance. Nevertheless, circumstances do sometimes occur when, for example, a decision to turn or to overtake is taken suddenly and a delay of one second in the signalling system may be of vital importance.

CONCLUSIONS

The experiments described in this paper show that the color of a direction signal is important and that under adverse conditions amber indicators were better than white or red. Experiments using flashers of a range of intensities up to 400 candelas indicate that an intensity of at least 100 candelas is required in daylight; at night a lower intensity is probably effective. Other work suggests that intensities of more than 500 candelas are likely to prove glaring at night.

At night, when the experimental vehicle, with headlights on, was viewed from the front, the amber ear was the most effective indicator. From the rear (when the stop light was not in use) the low-mounted amber and the amber ear were equally effective.

By day, the amber ear and the semaphore arm were better than all other indicators. It is concluded, therefore, that over the wide variety of conditions tested the amber-ear indicator is the most effective.

A rear indicator was found to beome less effective as it was moved nearer to a stop light; when the separation, center to center was less than 9 in. the decrease in efficiency was marked; there seem to be advantages in mounting signals at driver eye level.

It is shown that the side-mounted indicator is likely to be of help to cyclists and motorcyclists who are the chief victims of serious and fatal turning-car accidents at road intersections.

Some experiments have also been carried out to test the comparative merits of direction signals when illuminated by a steady light or by a flashing light of equal intensity, in each case the housing being the same as that used for the flashing light. Under some conditions flashing lights were slightly more effective; under others, steady lights were better, but differences were small. However, no change from the existing practice of using indicators that flash can be recommended because of the limited scope of the experiments.

In all problems of this kind standardization is of fundamental importance so that an observer knows as far as possible where to look and what to expect as a signal. It is important, therefore, that one type of indicator should be selected for general adoption and that alternatives should be avoided. Associated with standardization is the importance of not using the same color for stoplights and direction indicators. All direction indicators therefore should be amber and this color should not be used for other vehicle lights.

The conclusions of the investigation are therefore that:

(1) Direction indicators should be amber in color and this color should not be used for other vehicle lights.

(2) At night the indicator should have an intensity of between 100 and 500 candelas.

(3) Indicators are best mounted on the side of a vehicle roughly at the level of the driver's eye. They should emit light forward and backwards and send an appreciable amount of light at right angles.

(4) No consistent evidence in favor of a flashing rather than a steady indicator light of equal intensity has been found and no change in existing practice can be recommended.

(5) Uniformity of type of indicator, position, intensity and rate of flash are important and means for ensuring that standards are adhered to are desirable.

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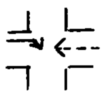
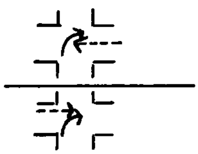
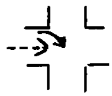
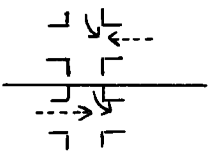
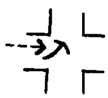
Appendix A

THE MANEUVERS RESULTING IN FATAL AND SERIOUS ACCIDENTS INVOLVING A CAR AT A JUNCTION (1954)

In collisions between a car and another vehicle there are roughly 700 people a year killed and 9,000 seriously injured. In 1954, 5,733 of such accidents occurred at junctions, in 1,653 of which a car was turning, and they are analyzed in the following table. There were comparatively few vehicles fitted with flashing indicators in that year.

Type of Collision[a]	Type of Vehicle Colliding with a Turning Car						
	Other Car	Pedal-Cycle	Motor-Cycle	Goods Vehicle	Public Service Vehicle	Other	Total
1 	89	125	397	23	3	1	638
2 	89	66	261	28	13	4	461
3 	43	14	232	12	2	-	303
4 	24	21	30	8	6	-	89
5 	4	20	31	-	2	1	58
6 Other collisions involving a turning car	10	38	43	12	1	-	104
Total involving turning cars	259	284	994	83	27	6	1,653
Collisions not involving a turning car	640	1,368	1,241	623	181	27	4,080
Total	899	1,652	2,235	706	208	33	5,733

[a]Key Car ⟶ Other vehicles - - →

Appendix B

MEAN RESPONSE TIMES OF SUBJECTS TO FLASHING AND STEADY TURN SIGNALS SEEN AGAINST VARIOUS BACKGROUNDS

Conditions of Test		Mean Response Times in Seconds To:					
Time	Background Lights	Amber Ear		Low-Mounted Amber Indicator		Number of Subjects Tested	Number of Responses per Mean
		Flashing	Steady	Flashing	Steady		
Day[a]	Neutral (not operated)	1.41 (1.46) (1.36)	1.48 (1.54) (1.42)	1.43 (1.48) (1.38)	1.40 (1.46) (1.35)	27	162
Day[b]	Flashing	1.33 (1.36) (1.30)	1.29 (1.32) (1.26)	1.42 (1.45) (1.39)	1.38 (1.41) (1.35)	8 repeated 3 times	432
	Steady	1.30 (1.33) (1.28)	1.41 (1.44) (1.37)	1.37 (1.40) (1.35)	1.39 (1.42) (1.36)		
Night	Flashing	1.78 (1.83) (1.74)	2.00 (2.05) (1.95)	2.11 (2.17) (2.05)	2.05 (2.11) (1.98)	20	480
	Steady	1.69 (1.72) (1.66)	1.94 (1.99) (1.90)	1.82 (1.86) (1.78)	1.97 (2.02) (1.92)		
Day	Moving vehicles road test	1.46 (1.54) (1.39)	1.39 (1.47) (1.32)	1.51 (1.57) (1.45)	1.40 (1.45) (1.34)	8	120

(During the static tests by day and the mobile test the rear of the test car was seen; at night the car with dipped headlights was turned to face the subject.)

The means given above are geometric means. The limits of the range of plus and minus one standard error of each are also given in parentheses.

[a]These results have been combined from three tests, the only difference between which was that the angle of separation between the test car and the leveling task was varied (see Fig. 1). Different subjects took part in these three tests.

[b]As above, except that the same eight subjects repeated the test for each of the three angles.