Running lights – conspicuity, glare and accident reduction

by Kåre Rumar

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FOREWORD

In the 60:ies it was quite a discussion in USA concerning the possibility to improve safety by using day-light running lights. The Greyhound Bus Company was one of the pioneers to use running light as a safety measure.

The idea was taken up concerning motorcycles in many countries. But it is so far only in Sweden and Finland that running lights are compulsory for both automobiles and motorcycles. Canada and Norway are showing considerable interest.

This report presents the research arguments behind the Nordic efforts and actions concerning running lights. It reviews and reports behavioural studies and accident studies carried out in Sweden and Finland as well as in other countries. The effect on accidents of the laws passed is presently being followed up.
<table>
<thead>
<tr>
<th>CONTENTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background</td>
<td>1</td>
</tr>
<tr>
<td>Detection of cars in rural traffic</td>
<td>2</td>
</tr>
<tr>
<td>Experimental studies of vehicle detection</td>
<td>4</td>
</tr>
<tr>
<td>Running light effect on accidents</td>
<td>8</td>
</tr>
<tr>
<td>Conclusions</td>
<td>10</td>
</tr>
<tr>
<td>List of references</td>
<td>12</td>
</tr>
</tbody>
</table>
Background

It is more or less a truism to state that the main part of the information collected by road users in traffic is of visual nature. It is likewise generally accepted that a considerable part of the traffic accidents are caused by the fact that the road users do not detect each other in time.

The visual system is constructed to react to contrasts and contrast changes in the visual field. Blackwell (1946) made thorough studies of the contrast sensitivity. He showed that if the brightness contrast between a target and its background is lowered also the probability for detection of the target is diminished. The periphery of the eye is less sensitive to contrasts than the central parts. When the ambient illumination levels are lowered (dawn, dusk, twilight) the contrast sensitivity of the eye is diminished. On top of these deteriorations situations often occur when the illumination in the visual field is very unevenly distributed. This may lead to misadaptation (bright sky, dark road situation) or to glare (low sun). Such situations further lower the visual contrast sensitivity.

The ambient illumination is consequently very important for the contrast conditions. The ambient illumination is due to the sun's altitude and the weather. The sun's altitude is a function of latitude and season while weather has a more complex background.

The closer to the poles the longer are the twilight periods as are the periods with low sun and generally low ambient illumination. The twilight period in June is e.g. in Stockholm (60°N) 215 minutes and in Rome (40°N) 65 minutes. In December the ambient illumination by noon is five times higher in Rome than in Stockholm.
With this as a background it is natural that the interest for daylight running light to increase visual contrast between the vehicle and the background has been met with special interest in the Nordic countries and in Canada. A special working group within the Nordic Road Safety Council is studying the problem and has produced two reports concerning running lights on motorcycles (NTR 1975) and on cars (NTR 1976).

In the following a series of studies of daylight running lights is reported. In the first part the detection conditions in real rural traffic are observed. In the second part vehicle detection in the peripheral and central visual field is studied as a function of running light characteristics and level of ambient illumination. In the third part the effect of daylight running light on accident statistics is analyzed based on Finnish data. Finally conclusions are drawn and the present status is described.

Detection of cars in rural traffic

Dahlstedt & Rumar (1973) studied the conditions characteristics at the moment of detection of oncoming vehicles in rural daylight driving in Sweden. The subjects were driving along normal two lane roads in central Sweden. As soon as they detected an oncoming vehicle they pressed a button which released the shutter of a telelens equipped camera with colour film and started a tape recorder. In the tape recorder the driver verbally described what he experienced to be the cause to detection. The experiments were done in the 60:ies when very few cars had low beams on during daylight. On the basis of the photos and the recordings the causes to detection during summer and winter conditions were classified proportionally as follows:
Summer (no low beam cars)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td>Brightness contrast</td>
<td>52%</td>
<td>(70% positive, 30% negative)</td>
</tr>
<tr>
<td>Colour contrast</td>
<td>16%</td>
<td></td>
</tr>
<tr>
<td>Reflexes</td>
<td>21%</td>
<td>(in paint, chrome or glass surface)</td>
</tr>
<tr>
<td>Silhouette</td>
<td>3%</td>
<td>(normally towards sky)</td>
</tr>
<tr>
<td>Motion</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>100%</td>
</tr>
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Winter (with snow on the ground)

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<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brightness contrast</td>
<td>40%</td>
<td>(40% positive, 60% negative)</td>
</tr>
<tr>
<td>Low beam</td>
<td>25%</td>
<td>(= all cars with low beam)</td>
</tr>
<tr>
<td>Reflexes</td>
<td>17%</td>
<td></td>
</tr>
<tr>
<td>Silhouette</td>
<td>14%</td>
<td>(sky plus snow fields and haze)</td>
</tr>
<tr>
<td>Motion</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>100%</td>
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These observations show the importance of brightness contrast generally and of low beams as running lights specifically.

Based on these observations a systematic study of car conspicuity as a function of colour of car and background and low beams on/off was carried out. The conspicuity criteria used was primarily detection time of a mock up vehicle with various colours as photographed on roads against various backgrounds. Besides these laboratory measurements also some subjective conspicuity ratings were done.

In short the results showed very strong interactions between colour of vehicle and colour of background. The best conspicuity is obtained with different car colours depending on the colour of the background. But - and this was maybe the most interesting result - a conspi-
cuity equal with the one obtained with the best colour in each situation could be obtained for all colours if the vehicle had lights on. However, since this was a laboratory experiment the validity is not known.

Experimental studies of vehicle detection

Allen & Clerk (1964), King & Finch (1969) and Hörberg & Rumar (1975) have studied central conspicuity as a function of ambient illumination level and running light intensity. The conclusion is that when fixated also running lights with low intensities (~100 cd) increase vehicle conspicuity - especially under levels of low ambient illumination.

From behavioural and safety point of view it can be argued however the most interesting detection situation is not the central but the peripheral one. The main motives are that when fixated also very low contrasts are detected (also vehicles without running lights). In other words - when vehicles appear where they are expected, where road users focus their attention the effect of running lights is probably very limited, vehicles are easily detected anyway and no accidents occur. But when vehicles appear where they are not expected they are not fixated but appear in the peripheral field of vision where contrast sensitivity is considerably lower. In such situations the accident risk is high and the favourable effect of daylight running lights should be good.

Hörberg & Rumar (1975) have studied systematically the peripheral (30° and 60°) detection distance of various running lights (intensity, colour, area) at various levels of ambient illumination (bad daylight, twilight). Figure 1 shows the experimental set up and figure 2
Figure 1. Experimetal set up in the daylight test of peripheral vehicle detection distance. The visual task consisted of successively projected letters and digits that the subject should read.

The angles chosen can be taken as representative for the position of rear view mirrors or for the attention angles normal in urban traffic (street crossings).

The running lights tested were special running lights of 50 and 150 cd each, normal halogen Continental European low beam of 400 cd each and high beam of 60 000 cd each. The luminous areas used for the lower intensities were 70 and 200 cm² each.

The results show that in 30° and 60° peripheral vision the lower intensities (50 and 150 cd) do not seem to have any effect. At those levels luminous areas do not seem to influence conspicuity. At 30° the low beam has a considerable effect and the high beam is very effective. At 60° however low beam has no effect.
In some special studies it was shown that although yellow colour was rated as having better conspicuity than white light no real difference could be measured at the experiments. It was further indicated as a side result that some glare problems occurred with the high beams also under the general ambient daylight (sky) levels prevalent during the experiments (3 000 - 6 000 lx).

In a special study car and motorcycle conspicuity was
compared at 6 000 lx ambient illumination and at 30° peripheral vision. The running light of the motorcycle was low beam (ca 250 cd). Without running lights the detection distance for the motorcycle was 83 meters and for the car 175 meters. When the motorcycle used low beam the detection distance increased to 183 meters – roughly equal to that of the car without running lights. Janoff et al (1970) report that the number of car drivers reporting having detected an oncoming motorcycle increased two to three times when the motorcycle had its low beam on.

Hörberg (1977) in a special study of peripheral (20°) detection distances under twilight conditions (100 – 2 000 lx) reports that under no snow conditions even such a weak running light as 100 cd has considerable effect at ambient illumination levels lower than about 800 lx. In snow conditions on the other hand even a 300 cd running light has no marked effect above about 600 lx ambient illumination and a 100 cd running light has no clear effect until the ambient illumination is lower than about 350 lx.

Attwood & Angus (1975) and Attwood (1976) in Canada have shown that against some hypotheses the possibilities to determine the position on the road of an oncoming car are improved by turned on low beams. They also report that according to perceptual laws a vehicle with lights is estimated to be somewhat closer to the observer than a vehicle without lights. The "lights on" condition on oncoming cars resulted in somewhat safer (longer) marginals in overtaking situation. Also possibilities correctly to judge motion direction of distant vehicles should be improved by running lights.

It is generally accepted that in night driving within at least well stationary lighted areas oncoming low
beams deteriorate the visual conditions. But on the other hand parking lights are often not conspicuous enough. Also here a running light could be a solution - this is the so called city beam. But could the daylight running light also be used as a night driving city beam? In order to study this problem Hörberg & Rummar (1975) carried out a series of experiments. The results show that the glare effect (detection distance of a dark obstacle) of a 150 cd city beam is only about half that of a low beam. On the other hand peripheral (80°) detection distance of a car with low beam is about 50% longer than that of a car with 150 cd city beam. In conclusion it could be said that if it were not for the visibility of reflective materials on road markings, road signs, vehicles and unprotected road users the city beam should have an intensity which is considerable lower than that of a daylight running light. This has also been suggested by several authors (e.g. Balder 1957, Dahlstedt 1973, Fisher 1974, Hisdal 1973, Jehn 1963, Nielsen 1974, Schreuder 1974).

Running light effect on accidents

In the 60:ies several more or less controlled studies of the effect of running lights on accidents were carried out in USA. The best known is probably the Greyhound bus study from 1962. The company reported at 10% decrease of accidents. Allen (1965) reports from a questionnaire study of about 50 companies that the accident reduction for vehicles with running lights was close to 40%. Cantilli (1968) studies the running light accident effect of vehicles belonging to Port of New York Authority and reports a reduction of 18%. Allen (1970) states that a Chicago taxi company obtained an accident reduction of 12%. Janoff et al (1970) in the probably best controlled accident study of running lights so far reports about experience from four USA-
states with compulsory running lights for motor cycles and concludes that the accident reduction for motor
cycles due to running lights was 4%. Attwood (1975) describes a large Canadian study in progress with 350
matched cars. In this study the accident effect as well as the practical, technological and economical effects
will be studied.

But the most recent, largest and best controlled accident study is the one carried out by Andersson,
Nilsson & Salusjärvi (1976) on Finnish data 1968-1974. As a result of successive measures taken in Finland
beam during daylight in rural areas during the winter half-year has successively increased so that during
the compulsory period it was 93-99%. The basic hypothesis in the study is that during the winter half-
year running lights should affect multiple accidents in daylights, while other accident types should not be
affected and could consequently be used as controls. The control groups used are - multiple accidents in
darkness, single accidents in daylight, single accidents in darkness.

For these four groups a regression analysis was made for the period 1968-1974. The results show

1. Multiple accidents in daylight decreased by 32%
2. Multiple accidents in darkness decreased by 4%
3. Single accidents in daylight decreased by 4%
4. Single accidents in darkness increased by 6%

The overall accident reduction is of the size of 10%.
By calculating the ratio

\[ \delta = \frac{\text{number of daylight multiple accidents}}{\text{number of daylight single accidents}} \times \frac{\text{number of darkness multiple accidents}}{\text{number of darkness single accidents}} \]

the effect of measures having general influence, multiple/single influence and daylight/darkness influence on accidents may be eliminated. With this method of analysis a reduction of daylight multiple accidents of 36% during the period 1968-1974 is reported. A more detailed analysis of accident types shows that accidents with meeting direction decreased by 28%, accidents with crossing direction decreased by 17% and accidents with the same direction increased by 9%. Also daylight pedestrian accidents decreased during the period (24%).

The study which was initiated by the above mentioned Working Group within The Nordic Road Safety Council concludes that although accident analyses such as this one always are difficult due to other measures and variation in external conditions the results strongly indicate the favourable effect of running lights.

Conclusions

In Sweden the use of running lights during daylight was considerable especially in lowered daylight conditions (e.g. twilight, bad weather). In the winter half 1975/76 the usage of running lights in rural areas in Sweden was studied by Sävenhed (1977). He reports that on the average 3 cars out of 4 use low beams or special running lights. In poor illumination conditions the usage is above 90% while in good illumination conditions 1 of 2 cars have lights on.

With this as a background it is not too amazing that
from October 1, 1977, low beam or special running lights are compulsory in Sweden during daylight. As mentioned above Finland already has the law, Denmark has it for motorcycles (as several other countries e.g. France) and Norway is expected to follow in 1979.

Two problems concerning the running lights remain to be solved. The first one is the optimal characteristics of a running light. A special Swedish committee is presently drafting the suggestions for a standard. The main question is the intensity interval. The present proposal is 300 - 800 cd. In this context the integration with a city beam is also discussed but no conclusion has been made.

The other problem concerns the vehicles for which running lights are presently not compulsory (e.g. tractors, mopeds). It is a reasonable hypothesis that the conspicuity for those vehicle categories will be relatively lowered when a majority of the vehicles in traffic use running lights. The above mentioned Working Group within The Nordic Road Safety Council is studying these questions.
List of references


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