Traffic signage conspicuity

The conspicuity of traffic signs will be different between night and day, that is self-evident enough. But what factors have the most effect and how, as a result, can lighting professionals improve conspicuity? A study by UCL, presented at last month's Professional Lighting Summit, has looked into this area

By Margareth Sunjoto and Jemima Unwin

Traffic signs, as we all know, are created so that drivers can navigate on the road. According to the government's *Traffic Signs Manual*, drivers rely on traffic control devices, such as signs, for information and guidance (Department of Transport, 2008). Their role, therefore, is to deliver information clearly and precisely on time, so that they are speedily understood.

However, the efficiency of traffic signs in the urban environment depends on factors that are difficult to control. Urban areas usually have a greater number of buildings and vehicles, which could create visual distraction and clutter in the background behind the signs.

This effect could be either to make sign searching more difficult, or have the opposite effect, as the simply-designed sign could stand out from the background and become more visible.

Therefore, conspicuity is a good measure of how successful a sign can be in 'guiding' drivers. Conspicuity is defined as the quality of an object or a light source to appear prominent in its surroundings.It is a measure of how a sign can attract (attention conspicuity) or gain (search conspicuity) the driver's attention (CIE International Lighting Vocabulary).

PREVIOUS RESEARCH

Previous research (summarized in the table opposite), has found that conspicuity is determined by several factors related to:

- Size difference, particularly because the human eye tends to see closer objects that provide a large visual angle
- Luminance differences between the target object (traffic signs) and its background
- Complexity and density of background patterns
- Colour differences

YEAR	RESEARCHER	FINDINGS
1978	Cole & Jenkins	Cole & Jenkins Larger target objects were judged to have perceptual better defined edges, and edge definition was an important determinant of conspicuity
1979	Cole & Jenkins	Conspicuity is not simply a matter of the physical characteristics of the object. The object must be considered in relation to its background. Not yet able to specify the background parameter
1980	Hills	An object that is highly conspicuous in one environment can readily be lost in another
1982	Cole & Jenkins	No satisfactory explanation can be given to the effect of background density on target detectability, but a tentative suggestion could be that subjects need to distribute their attention over a wide peripheral area in order to perform well
1986	Jenkins	Effect of contrast with local background – border treatments increased the conspicuity of the sign, but the increase was not statistically significantly greater than the untreated sign having the same overall dimensions
1987	Schwab & Mace	The more complex the background, the shorter the detection distance
2001	Ho et al	The search for a sign is not equally easy during night time and daytime
2001	Paulmier et al	When the visual complexity of the near background of target increases, its visibility level must be increased to achieve higher detection rate
2011	Porathe & Strand	Introducing conspicuity index
2014	Cavalcante et al	In streetscapes, high complexity is associated with the presence of high contrast object

▲ **Figure 1**. Findings in conspicuity research

Although the past studies are informative, research in the field would benefit from further studies. For example, investigation of the influence of luminance contrast and colour difference between the sign and the background could be valuable.

An investigation that compares daytime and night-time conspicuity could also be useful because, although it seems to be obvious that the conspicuity of signs is different between night and day, the importance of various parameters may change.

By exploring this issue in more detail, the effectiveness of signs for both daytime and night-time conditions can be understood. The following experiment was designed in order to do this.

METHODOLOGY

A controlled indoor experiment was designed based on the outcome of a field observation which identified sites in London for study, and two pilot studies which refined the experiment method, to ensure clarity in the procedure.

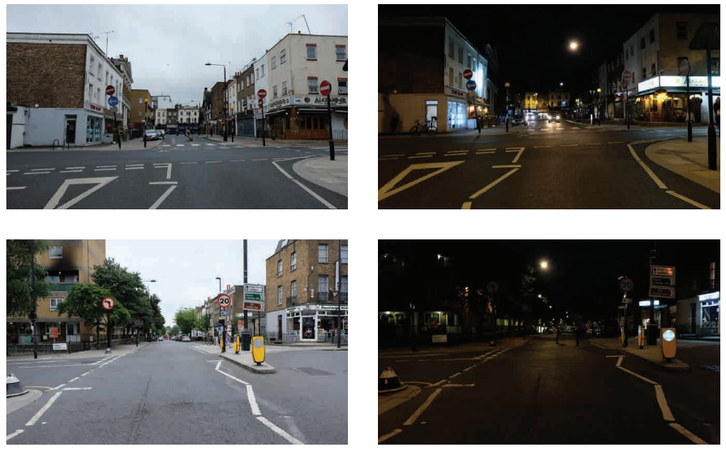
The decision to complete an indoor controlled experiment was taken partly because of the feasibility of this approach within the time constraints of an MSc dissertation. Also, a field study in real traffic is considerably more difficult to control because of the varying number and speed of vehicles in the background. An indoor experiment involving a still scene meant participants have the same experience, so patterns in their responses can be identified.

A total of 24 subjects from the ages of 20-years-old to 54-years-old participated. All had either normal vision or vision corrected with glasses or contact lens. No participant in the study was reported to be colour blind.

The experiment was a visual search task where eight different scenes from London urban areas were presented under daytime and night-time conditions.

DAYTIME VIEW

NIGHT-TIME VIEW



▲ **Figure 2**. Examples of the scenes used for the experiment

THE SIZE OF A SIGN HAS A HIGHER INFLUENCE ON CONSPICUITY COMPARED TO OTHER PARAMETERS. DIFFERENT TREATMENT OF SIGNS IN DAYTIME AND NIGHT-TIME CONDITIONS SHOULD BE CONSIDERED TO INCREASE THE CONSPICUITY OF TRAFFIC SIGNS

Every scene appeared for 200 milliseconds, and was repeated twice in random order between night and day to reduce bias from order effects.

A blank screen with a '+' symbol in the centre appeared after each scene to help participants fixate before moving to the next scene. Participants were asked to detect any traffic signs they saw in the scene and record the type and occurrence of sign on an answer sheet provided.

Four parameters were tested: size/distance of sign to driver; background complexity; relative luminance contrast; and

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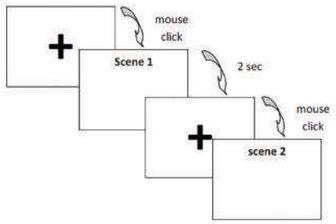
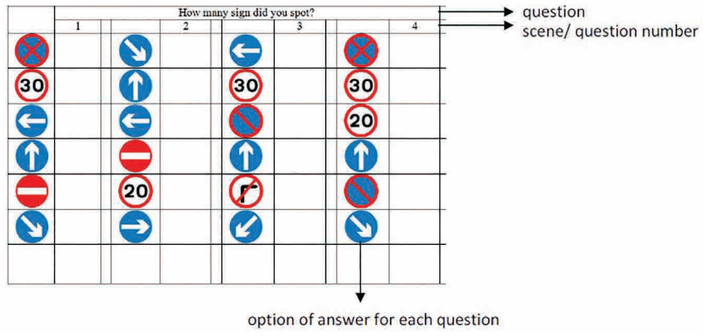
Traffic signage conspicuity

colour difference between the sign and its immediate surroundings. Figures 3 and 4 below illustrate this approach.



▲ **Figure 3**. The procedure for the visual search task

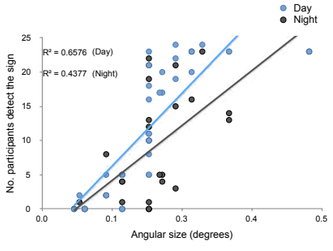


▲ **Figure 4**. The answer sheet. Participants were asked to detect any traffic signs they saw in the scene and record the type and occurrence of sign

FACTORS THAT AFFECT CONSPICUITY

1) Size and the distance from the sign to subject's eye

Size and distance are strongly related because the diameter of the sign is bigger if it is closer to observer's eye. The scatter plot below (Figure 5) shows a consistent pattern where the conspicuity of the sign increase as it is closer and therefore appear bigger to subject's eye. It declines as the sign appears smaller.



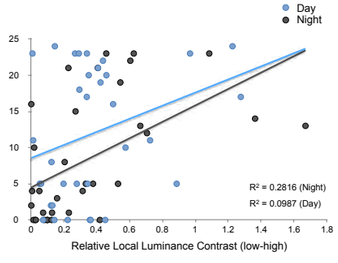
▲ **Figure 5**. Daytime and night-time detection and distance and size, shown through a scatter plot

This finding agrees with previous research (Jenkins and Cole, 1978). It also can be suggested that these variables might be easier to control and adjust under different conditions than other parameters. The majority of the inconspicuous signs are signs located quite far back in the scene in the image presented.

2) Luminance contrast

Previous study suggests that providing a high contrast on the edge of the sign could increase its conspicuity and therefore isolate uncertainties from the immediate background (Jenkins, 1986).

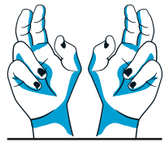
In this research, the term luminance contrast is defined as the contrast between sign and its immediate background measured ± half of the diameter.



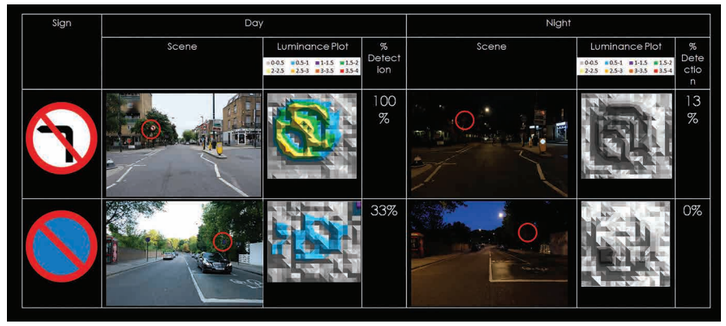
▲ **Figure 6**. Daytime and night-time detection and luminance contrast, shown through a scatter plot

Local luminance contrast seems to have an influence in determining conspicuity in the night-time condition. As Figure 6 shows, participants tend to detect more signs as local luminance contrast increases, particularly above 1 cd/m2. Slightly fewer participants detected signs with high luminance contrast in the daytime scenes.

To investigate further, a series of relative luminance contrasts between the sign and its immediate background were plotted in surface plots. This was used to compare signs and to illustrate the contrast distribution between the sign and its local surrounding. The surface plot of each sign was analysed by a visual appraisal. Examples are shown opposite in Figure 7.



BACKGROUND COLOUR PATTERNS CAN INFLUENCE THE EFFECT OF COLOUR DIFFERENCE (AS CAN BE SEEN IN CAMOUFLAGE CLOTHING). FOR EXAMPLE, THE CONSPICUITY OF THE SAME SIGN WITHOUT CHANGING ITS SIZE AND LOCATION MIGHT BE DIFFERENT IF AN URBAN SCENE IS CHANGED TO A RURAL SETTING AREA



▲ **Figure 7**. The relative luminance of signs under daytime and night-time scene, shown through a surface plot

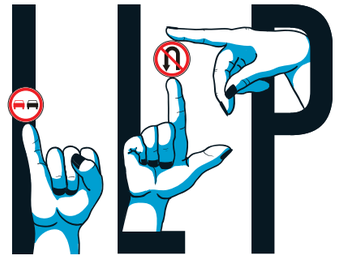
The relative luminance contrast map illustrates that several signs with high contrast on the edge have better conspicuity.

However, some of the signs are conspicuous, despite less immediate background luminance contrast in daytime. The results tend to agree with statistical analysis showing that local luminance contrast at night matters more than in daytime. This make sense because in daytime the overall scene still clearly visible.

3) Colour difference

Because of less influence of luminance contrast in daytime scenes, perhaps in these cases colour difference contributes to sign detection? However, this supposition is only supported by the surface plots for local colour difference (in lab colour space).

▲ **Figure 8**. The colour difference of signs under daytime and night-time scene, shown through a surface plot

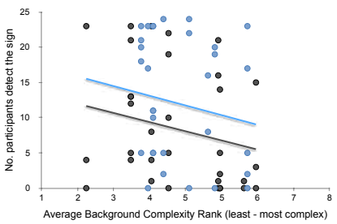


According to the visual appraisal of the surface plots, colour difference may have minor effects on conspicuity of signs for both day and night.

Although the form of the sign can be identified for most of the signs, this does not indicate that the sign was conspicuous, particularly if the sign is far away.

For instance, signs with a higher percentage of detection have a similar pattern of colour difference compared to less conspicuous signs. Less strong correlation between the conspicuity and colour difference is also stated in past research, where one sign could be conspicuous under one environment, but it can be inconspicuous in others (Hills, 1980).

Findings from this study tend to agree with previous studies. Background colour patterns can influence the effect of colour difference (as can be seen in camouflage clothing). For example, the conspicuity of the same sign without changing its size and location might be different if the scene is changed into a rural setting area.



▲ **Figure 9.** Percentage of daytime and night-time detection and mean background complexity score, shown as a scatter plot

4) Background complexity

Background complexity was the most difficult to characterise of all parameters. Because of the time constraints within this study, a ranking method was chosen in which participants ranked each scene in order of complexity.

As the scenes were typical environments found in central London, they were not too different from each other, which meant the ranking method created a simplistic difference between scenes which did not necessarily exist in reality.

Therefore, it is not surprising that correlation test results for this parameter were weak.

It is interesting to note that the trendlines point downwards, which although non-significant, reveals a possible trend for a lower proportion of people detecting the signs if the scene is more complex (with rank one as least complex and eight most complex).

Jenkins and Cole also argued that is difficult to characterise types of background complexity (Jenkins and Cole, 1979). Their other research also mentions that there is no satisfactory explanation for the effect of the background density on sign detectability (Jenkins and Cole, 1982).

Distributing driver attention over a wide peripheral area might be an alternative solution, as it could increase their per-

Traffic signage conspicuity

formance (Jenkins and Cole, 1982). Paulmier et al also argue that, when visual complexity of the local background increases, the target visibility must be increased to achieve better detection rate (Paulmier et al, 2001).

It can be argued that the most important factor affecting conspicuity in relation to the background could be the occurrence of objects of similar size, shape or colour in the visual scene. This would mean the sign is competing with similar objects for attention which could detract from their conspicuity.

Further research should explore this further and also be more specific in the definition of complexity.

CONCLUSION AND RECOMMENDATIONS

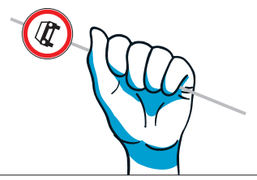
In summary, the size of the sign has a higher influence on conspicuity compared to other parameters within the constraints of this study. Different treatment of signs under daytime and night-time scenes should be considered to increase the conspicuity of traffic signs.

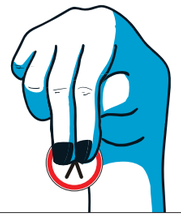
This research shows that each parameter might have a different impact on conspicuity during the day and at night – and it would be beneficial to investigate the effect of this in more detail.

The difference in difficulty in searching for and identifying signs between daytime and night-time scenes was evident as participants' performance slightly decreased during night-time. To illustrate, the same sign was detected 100% during daytime, but the percentage of people who detected the sign decreased to 96% at night, although it was the most conspicuous sign both during day and night.

From our experiment, it is suggested that each parameter has a different effect towards conspicuity. Notably:

- The size of the sign might strongly affect the percentage of sign conspicuity for both day and night.
- Luminance contrast seems to have more influence in the night condition and colour difference seems to have less of an effect for both conditions. However, the influence of background complexity was not proved in this study.





The conspicuity of traffic signs might be identified as a complicated area of research, yet it is considerably useful to road users.

This study does need to be caveated, notably in the fact it was, as already highlighted, conducted in an indoor environment. A further limitation was that participants for the experiment are mostly UCL students, not all of whom could drive.

Therefore, it would be advantageous to test the conspicuity of signs under real traffic situations, with active drivers as participants for further examination. This is particularly the case now that new cars have tighter headlight beam distribution, which could result in less spill light to light up reflective sign surfaces, possible reducing sign conspicuity.

In the case of our indoor experiment, a more advanced methodology is suggested to improve participants' experience, so to simulate driving in a real traffic environment. This could be achieved, for example, by providing an interactive simulated scene where the participant could click, using a computer mouse, on every sign that they detected. ■

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