White Light and Facial Recognition

A study by Peter Raynham and Torunn Saksvikrønning

Introduction

For many years now is has been suspected that white light was better for street lighting than the yellow light from High and Low Pressure Sodium Lamps. In fact there have been several reports on the benefits of white light[1][2][3][4]. There has also been a lot of work carried out investigating the change in sensitivity of the eye at low light levels. These studies[5][6][7] have developed the concept of mesopic vision. However, this is a phenomenon that only occurs in the peripheral regions of the eye, thus it was assumed that for many visual tasks under street lighting there would be no mesopic effect.

One of the key tasks for a pedestrian walking along a road at night is to recognise other pedestrians and work out if they present a threat, before they are so close that no evasive action can be taken. In order to see if white light is better than light from Sodium Lamps an experiment was conducted into the facial recognition distances under various light sources. The results of the study show that white light is significantly better for facial recognition than yellow light from sodium lamps.

Facial Recognition

The use of facial recognition distance as a measure of lighting performance for was a concept developed by van Bommel and Caminada[8]. They based their work on the concept of "zones of proximity" which had been developed by E T Hall[9]. Hall's work found that people only like other people to approach close to them if they have been recognised and he developed a series of zones and characterised them by the interpersonal reactions within them. Figure 1 is a diagram showing the Hall's "zones of proximity"

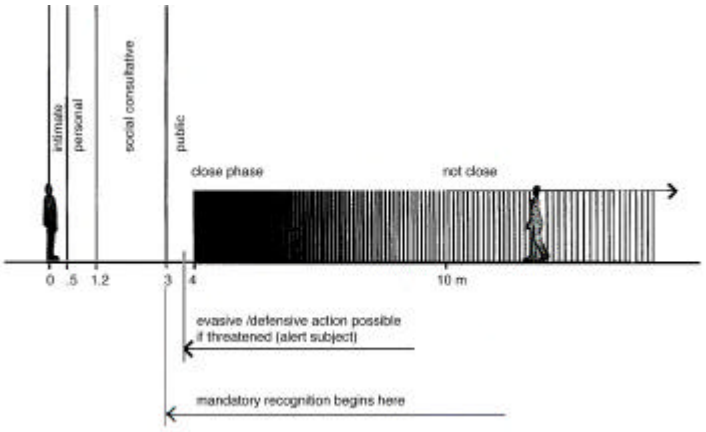

Figure 1 Hall's "zones of proximity"

From Hall's work van Bommel and his co-workers realised the importance of facial recognition to street lighting. They then found that Semi-cylindrical Illuminance (E_{sc}) was closely co-related to facial recognition and that an E_{sc} of 0.8 lux on a persons face would permit them to be recognised at a distance of 4 metres.

The work of van Bommel et al was closely examined by the committee that wrote the current British Standard on lighting for minor roads[10]. The committee realised that facial recognition was the hardest visual task for a pedestrian. They did not want to adopt semi-cylindrical illuminance as a measure but the calculated that for the bulk of British street lighting installations an E_{sc} of 0.8 lux corresponded to a horizontal illuminance of 50 lux.

However, at the time the standard was written no one considered the effect of changing the colour of the light source.

The Experiment

In order to investigate the effect of light colour on facial recognition distance a disused office was converted into a simulated street. The space was 23 m by 6m with a sloping ceiling running from 3m to 4 m. Figure 2 shows the space before the experiment was set up.

The space was blacked out using black theatrical drapes in front of the windows and around the walls. Lighting was provided by four 500mm diameter opal sphere luminaires mounted on 2.4 m columns. Figure 3 shows a layout diagram of the space and Figure 4 shows the space when lit using compact fluorescent lamps.

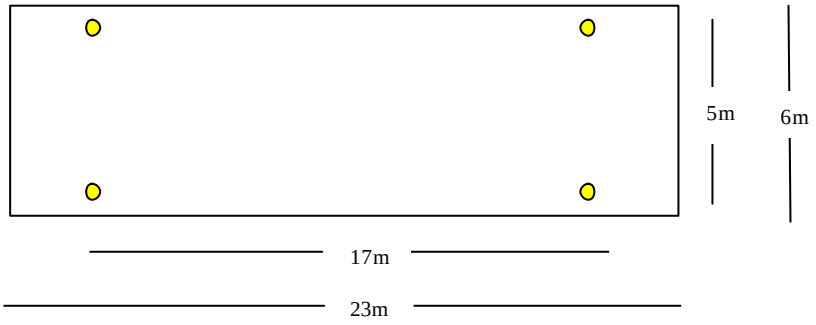

Figure 3 The Layout of the Space

Figure 4 the Experimental Space Lit with Compact Fluorescent Lamps

The luminaires were able to take a range of lamps and dimming gear was available for SON and compact fluorescent lamps. In order not to put too much light onto the ceiling the tops of the luminaires were sprayed black. Two experiments were carried out; in the first experiment the subject was asked to walk towards a person until their face could be recognised, in the second experiment the subject had to recognise two faces separated by 3 metres Figures 5 & 6 give the experimental layouts.

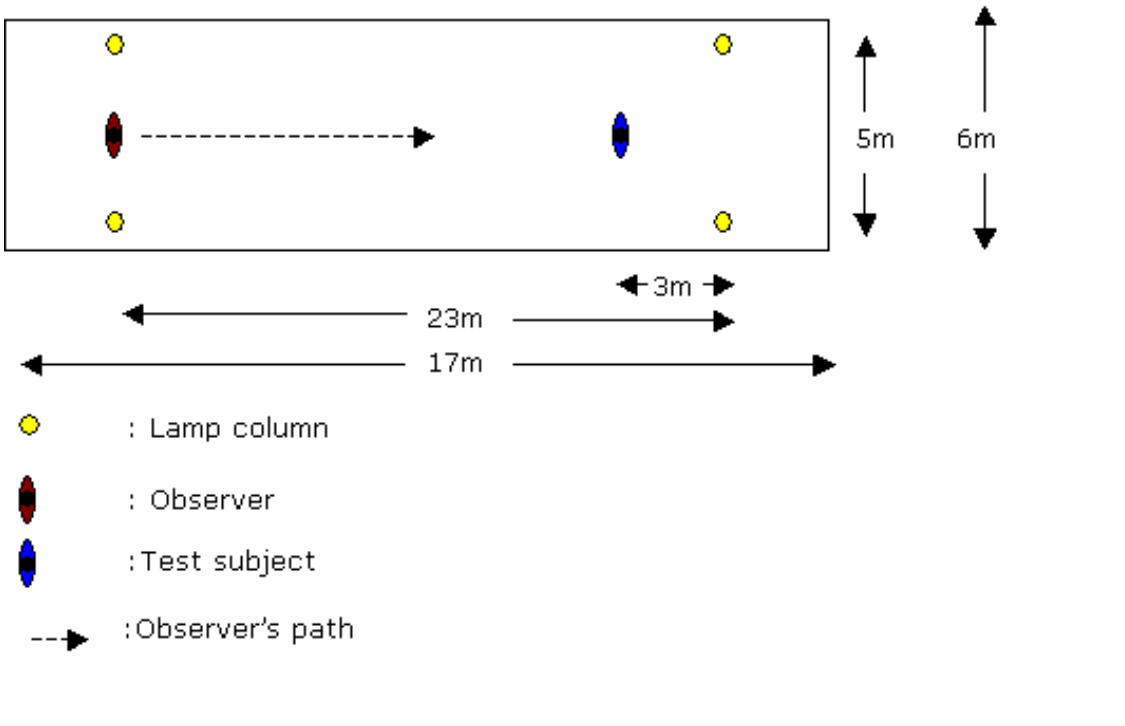

Figure 5 Layout of the First Experiment

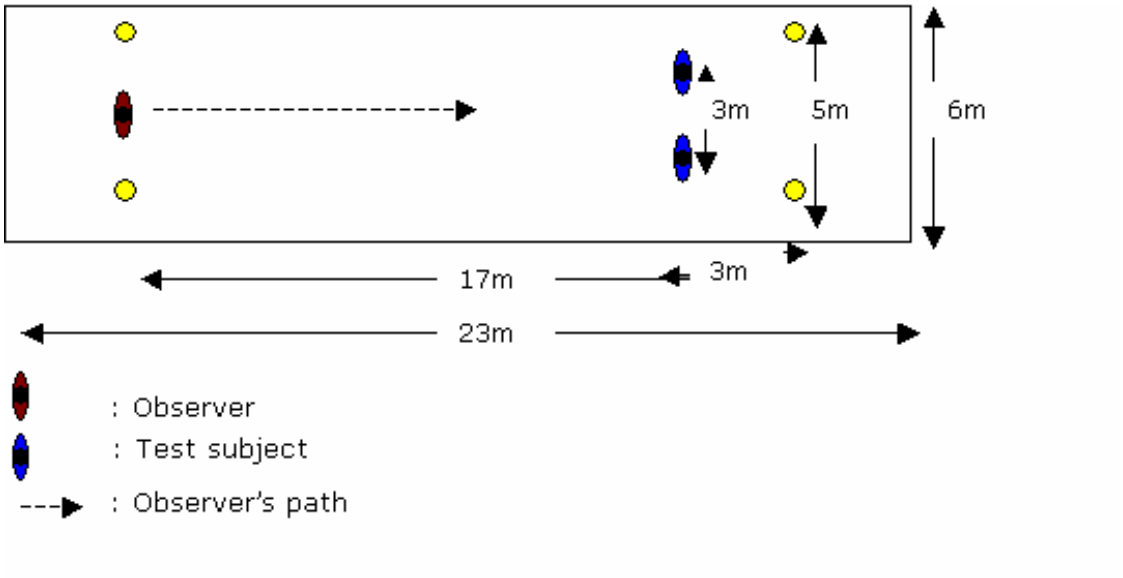

Figure 6 Layout of the Second Experiment

The first experiment was set up to replicate van Bommel's work, the second experiment was designed to get the observers to use their peripheral vision and thus it was hoped that some evidence of mesopic vision would be found.

Tests were carried out with 3 different light sources - a SON and two types of CFL, details are given in Table 1

Lamp Type	Colour Temperature (K)	Colour Rendering (Ra8)
Philips SON-T PRO 70W	2000	25
Philips PL-T 42W/827	2700	82
Philips PL-T 42W/840	4000	82

Table 1 Lamps used in the experiment

In the first experiment 8 observers were used, there were 3 women and 5 men with ages ranging from 15 to 59. For the second experiment there were 2 men and 4 women with ages ranging from 27 to 39. All observers had normal colour vision. In all the experiments the each of the observers had to recognize 3 different faces in each of the lighting conditions.

Results

The average recognition distances for all 8 observers are plotted in Figure 7 against the semi-cylindrical illuminance.

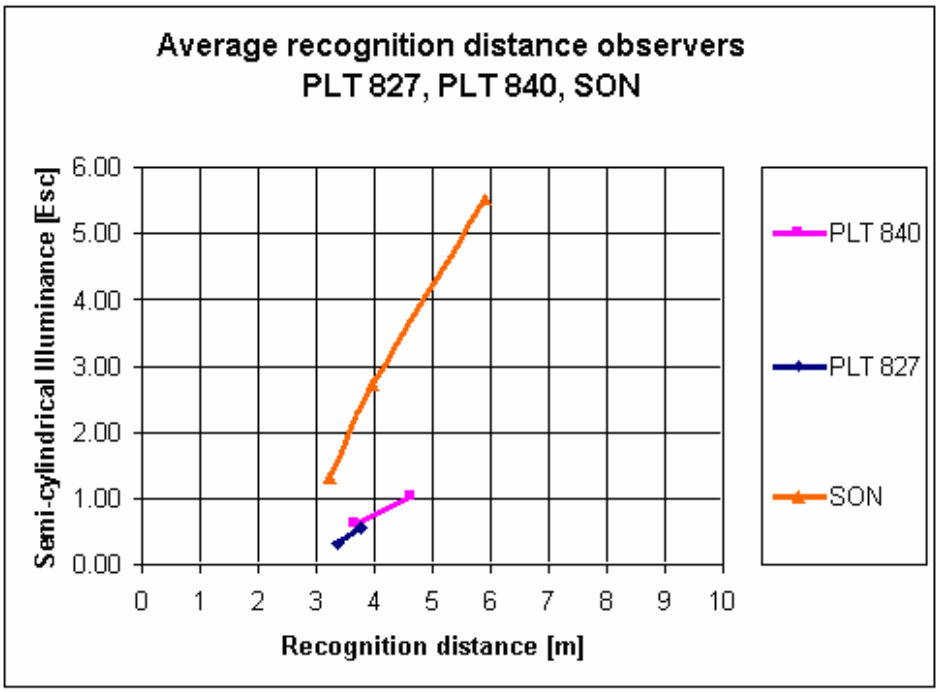

Figure 7 Average Recognition Distance

As can be clearly seen from Figure 7 much less light is needed with the compact fluorescent lamps to achieve a given recognition distance. However, the individual observers all had different performances, which relate to the quality of their eyesight and it was observed that there was a strong correlation between age and eyesight .

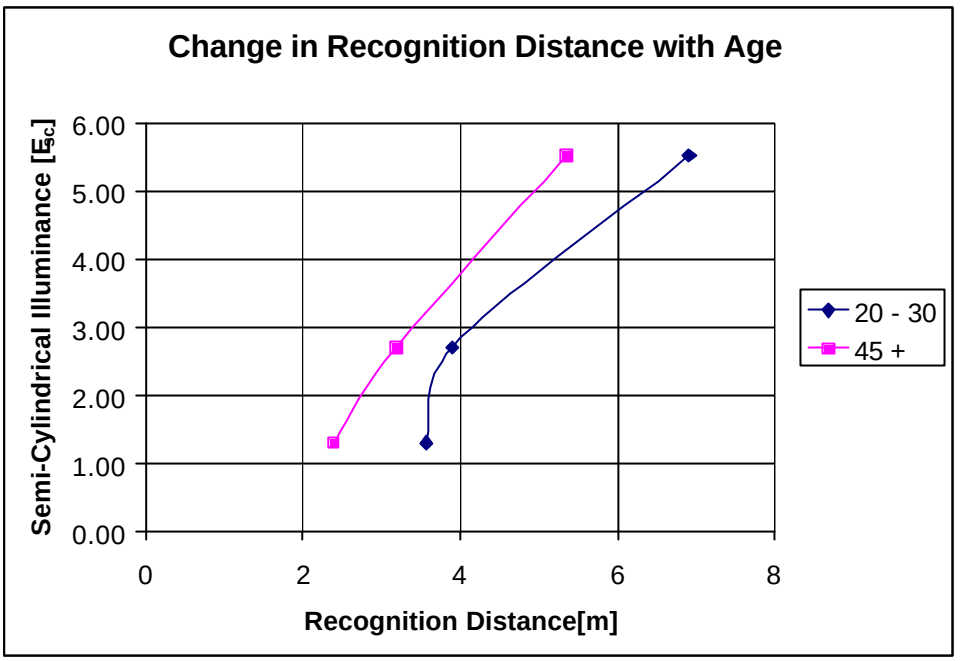

Figure 8 Change in Recognition Distance with Age

Figure 8 shows the performance of observers under SON light. The chart shows the performances of observers between 20 and 30 and compares them observes over 45. It can clearly be seen that observers over 45 needed significantly more light to achieve the same recognition distance as the younger observers.

There was no sign of mesopic vision being the cause of the change in the performance between the SON and the compact fluorescent lamps. If this had been the case then there would have been a difference in the performance between the two fluorescent lamps, the lamp with the 4000k colour temperature out performing the one with 3000K colour temperature. In fact no evidence of mesopic vision was found even in the experiment where the observers had to recognize two faces. Figure 9 shows the results of the second experiment superimposed on the results of the first experiment. As expected the recognition distances were shorter, this follows from the fact that it is visually harder to recognize two faces than it is to recognize one. However, if the performance had been governed by mesopic vision a greater difference if performance between the SON and CFL would have been expected, if anything there was less difference in performance.

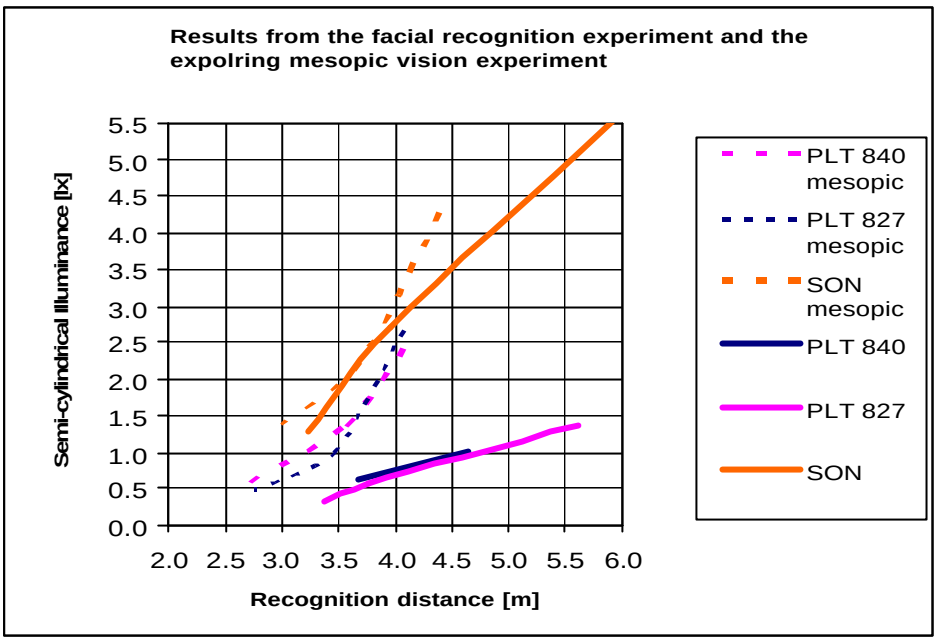

Figure 9 Results of the Second Experiment Superimposed on the Results of the First Experiment

Conclusions

For many years now concept of facial recognition has been embodied into the lighting design advice given in the British Standard[10]. The values arrived at were largely based on the work of van Bommel and his co workers. In this study this work has been revisited in order to assess the relative performance of different light sources. Figure 10 shows the comparison between our results and those of van Bommel.

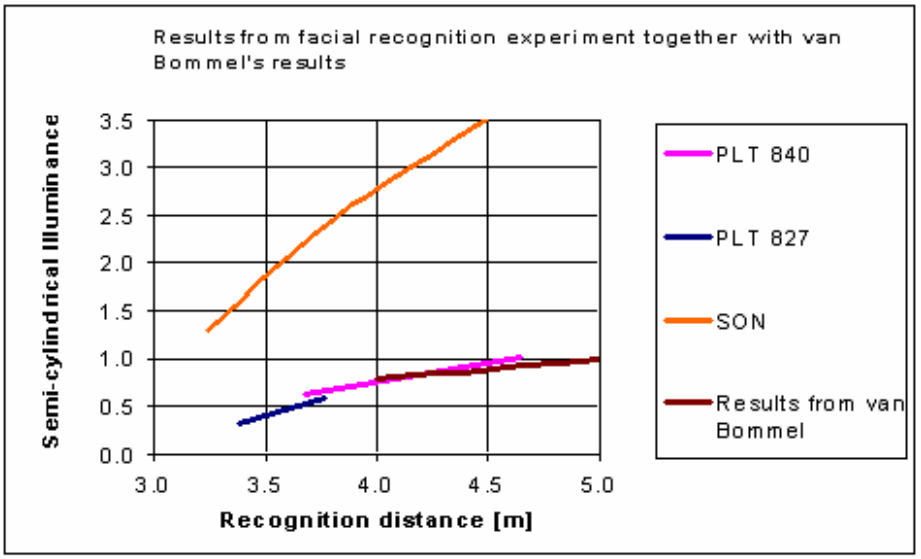

Figure 10 Results of our 1st Experiment compared to the Results from van Bommel

As can be seen the results that van Bommel achieved were very similar to those achieved with white light sources. Upon checked with van Bommel it was found that his work too had used a white light source, High Pressure Mercury Florescent lamps (MBF) with a colour temperature of 4100K and colour rendering of 51.

One of the key criteria of good lighting in pedestrian areas is the ability of people to recognise faces at a distance of 4 metres. Van Bommel found in his study that a semi-cylindrical illuminance at head height of 0.8 lux was required. In developing BS 5489 part 3 it was discovered that an E_{sc} 0.8 lux corresponded to a horizontal illuminance on the ground of 5 lux, and hence the minimum requirement for class 3/1 roads was set.

The findings of this study back up the work that lead to the British Standard for white light sources, however, this study also shows that if SON lamps are used the illuminance required is double that needed when using white light sources.

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