This is a repository copy of *Measuring the impact of lighting on interpersonal judgements of pedestrians at night-time*.

White Rose Research Online URL for this paper:
https://eprints.whiterose.ac.uk/81131/

Version: Accepted Version

Proceedings Paper:

Fotios, S. and Yang, B. (2013) Measuring the impact of lighting on interpersonal judgements of pedestrians at night-time. In: Proceedings of the CIE Centenary Conference “Towards a New Century of Light”. CIE Centenary Conference, 15-16 Apr 2013, Paris, France. , 990 - 998. ISBN 978-3-902842-44-2

Reuse
Items deposited in White Rose Research Online are protected by copyright, with all rights reserved unless indicated otherwise. They may be downloaded and/or printed for private study, or other acts as permitted by national copyright laws. The publisher or other rights holders may allow further reproduction and re-use of the full text version. This is indicated by the licence information on the White Rose Research Online record for the item.

Takedown
If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.

eprints@whiterose.ac.uk
https://eprints.whiterose.ac.uk/

MEASURING THE IMPACT OF LIGHTING ON INTERPERSONAL JUDGEMENTS OF PEDESTRIANS AT NIGHT-TIME

Steve Fotios, Biao Yang
University of Sheffield, Sheffield, UK
steve.fotios@sheffield.ac.uk

Abstract

This article discusses interpersonal judgements made between pedestrians after dark and in particular that judgements of intent are needed in addition to judgements of identity. The current study uses judgements of emotion from facial expression and body posture, and judgements of gaze direction, to evaluate the influence of lighting on visual cues to perceived intent. An experiment has been carried out in which judgements of emotion (using targets of facial expression and body posture) or gaze direction were sought after 1 s exposure using nine combinations of luminance and interpersonal distance. Initial results for judgements of emotion from facial expression suggest a minimum luminance on the face of 0.1 cd/m^2 if facial expressions are to be recognised at 4 m, increasing to 1.0 cd/m^2 for identification at 10 m. Using these data to suggest design light levels will require further discussion as to which task is the more critical and at which distance the critical task needs to be achieved.

Keywords: Road Lighting, Pedestrians, Interpersonal Judgements, Interpersonal Distance

1 Introduction

Lighting in residential roads is designed to meet primarily the visual needs of pedestrians and these are enhancement of their safety and perceived safety. One element of safety is the ability to make judgements about the intent of other pedestrians - whether or not they present a threat (Simons et al, 1987). This article presents a summary of investigations into the judgements pedestrians might make about one another after dark and how we might measure the influence of lighting on these judgements.

Recent work has tended to focus on facial recognition and whether lighting effects ability to identify a person. The current work extends this to judgement of intent, whether or not an approaching person is considered to present a threat. We consider this to be the more appropriate task for pedestrians after dark: recognition may play a part but is not the whole task. In parallel with this we are investigating the distances at which judgements about intent and identity might be ideally made.

The initial findings of an experiment carried to explore the relationship between luminance, target size (a proxy for distance) and ability to recognise emotion from facial expression and body posture, and gaze direction are used to explore the extraction of threshold light levels.

2 Facial Recognition

While the need to make judgements about threat was recognised by those who proposed the basis for design criteria (Simons et al, 1987), subsequent research within the lighting community has tended to target only facial recognition, and in particular whether it is affected by the spectral power distribution (SPD) of lighting. The results are mixed, with some studies suggesting SPD affects recognition whilst other studies do not (Fotios and Goodman, 2012; ILP, 2012).

One problem with past studies of facial recognition is that the methodology used in many of the studies leads to imprecise measurements (Fotios and Raynham, 2011). A common approach to measuring facial recognition under different lighting is to measure the distance at which a face is correctly identified (the stop-distance method). The variation in distance is achieved by having either the target or the observer move closer until recognition is achieved. The problem with this method is that the stimulus (target face) presented to the observer is always changing: with decreasing distance the details of the target face increase in size. This may lead to an under-estimate of the effect of SPD. Consider a lamp having a spectrum that is well chosen to enhance facial recognition: in the stop-distance procedure the target face will be 'recognised' at a greater distance, and thus smaller visual size, than a light of poorer facial recognition spectrum. What would be desirable is to compare recognition under different light sources but using target faces of consistent size.

The stop-distance method is subject to large errors because different targets and observers walk at different speeds and different observes take different amounts of time to make up their mind. Consequently, any delay in deciding that a face has been recognised can have different consequences. A proposed refinement to the procedure is to enforce walking of a constant, slow velocity (Hayduk, 1978). Constant fixation on the target during the stop-distance procedure is also likely to be an unrealistic proxy for real-world interpersonal judgements as there is a common tendency to avoid looking at others in some social situations.

Some facial recognition studies have used photographs of well-known people as test targets. Familiar faces can be identified with little effort, even from very low quality images (Hancock et al, 2000) and thus may not present a sufficiently demanding task to discriminate between light sources because they can be too-easily recognised.

Thus there are many reasons why the procedures used in past studies of facial recognition may have led to mixed results.

3 Interpersonal Distances

One further limitation of past studies of facial recognition is that they have not addressed the inter-personal distance at which it might be desirable to make judgements about other pedestrians. It is possible that at near distances any effect of SPD is not significant because the face is too large and on the plateau of visual performance. Thus, alongside evaluation of interpersonal judgements, this study is investigating the distance at which these judgements are desired (Yang and Fotios, 2012).

Caminada and van Bommel (1980) proposed a requirement to recognise the face of an approaching pedestrian at a minimum distance of 4m. This was apparently rounded from the minimum public distance proposed by Hall (1969), a distance of 3.7 m (12 feet) suggested to be the minimum distance at which an alert subject would be able to take evasive or defensive action if threatened. Others might consider this distance to be too short: Townshend (1997) suggests that once inter-personal distance is reduced below 15 m, the space in which we have time to react to avoid trouble, or simply an undesirable situation, becomes reduced beyond comfortable levels. Hall's apparent aim was to relate the interplay of the senses to interpersonal distances, it does not appear that he intended for the findings to be interpreted as evidence for marking critical distances; the evidence appears to be largely anecdotal and Hall himself acknowledges that it provides only a first approximation.

One question to ask is whether Hall's work, which did not specifically address vision at low light levels, is indeed a suitable basis for road lighting – is the minimum distance of 4 m still relevant to the situation of pedestrians walking at night under road lighting? Adam and Zukerman (1991) examined interpersonal distance at low and high light levels using a stop-distance procedure. They used two light levels, 1.5 lx and 600 lx. The mean comfortable distance was greater (1.17 m) under low illuminance than under high illuminance (0.53 m), indicating a preference for greater separation from unknown people at night-time than at daytime.

Fujiyama et al (2005) also used a stop-distance procedure to investigate comfortable distances under five illuminances, ranging from 0.67 lx to 627 lx. Ten stationary participants were asked to say "stop" when an unfamiliar person walking towards them felt uncomfortable. The results are reported only graphically and without error bars or similar to indicate variance. Mean comfort distances lie in the region of 4.0 to 5.2 m, with a slight trend to decrease at higher light level. Fujiyama et al report only a few sample statistical analyses. Comfort distances at 0.67, 2.8 and 5.5 lx are significantly longer ($p<0.05$) than that at 627 lx, but they did not find a significant difference between comfort distances at 12.3 and 627 lx.

The results from Fujiyama et al suggest longer comfortable interpersonal distances (4.0 to 5.2 m) than do the results from Adam and Zukerman (0.53 to 1.2 m). Both studies were carried out in interior spaces. One difference is the size of the laboratory: Adam and Zukerman used a smaller room, of dimensions 5.18 m × 6.1 m while Fujiyama et al used the Pedestrian Accessibility and Movement Environment Laboratory (PAMELA) which is larger (80 m^2). Thus there may be a stimulus range bias: Adam and Zukerman used a small room which resulted in a small estimate of comfort distance.

Table 1 presents interpersonal distances reported in past studies. These range from just over 1.0 m to 25 m and clearly this lack of consensus does not support the assumption of a 4 m critical distance. There are clear variations in comfortable interpersonal distances with light level and with the procedure used to measure the desired inter-personal distance (Yang and Fotios, 2012).

Table 1 – Interpersonal distances reported in past studies*

Study	Interpersonal distance	Method	Type of distance
Sobel and Lillith, 1975	1.2 m (Day-time)	Field study: behavioural observation	Collision avoidance
Adam and Zukerman, 1991	1.17 m (Dim) 0.53 m (Bright)	Stop distance in lab	Comfort distance
Fujiyama et al, 2005	5 m (Dim) 4 m (Bright)	Stop distance in lab	Comfort distance
Fujiyama et al, 2005	9 m (Dim) 6 m (Bright)	Collision avoidance distance in lab	Collision avoidance
Townshend, 1997	15 m (Night-time)	Field study: perceived comfort	Comfort distance
METRAC, 1989	25 m (Night-time)	Recommendation	Safety audit guide
Cutting and Vishton, 1995	30 m	Theoretical calculation	Action space

*These were either found by experiment or recommended from experience.

It is also worthwhile to consider what information can be gained at different distances. Yang and Fotios (2012) used an open question approach to find out what characteristics of other people were correctly reported at different distances. The targets were separate photographs of four people, with four distances (15 m, 35 m, 66 m, and 135 m) simulated by target size. The wall surrounding the target images was painted white and this had a mean luminance of 1.0 cd/m^2 and the luminance of the neutral surround on each image was approximately 0.5 cd/m^2. Features reported by the 20 test participants were placed into 14 categories. Figure 1 shows the results for two sets of features, these being characterised by apparent relationship with distance. One set of features (gender, hair length and body build) could be easily and equally well identified at the three closer distances, with a rapid decrease at the furthest distance. A second set of features (type and colour of clothing on lower and upper body, age group, and shoe colour) could be easily recognised at the closest distance, with a progressive decrease as distance increased. Facial expression was correctly identified by approximately 50% of test participants at the closest distance (15 m) but was not mentioned for any of the three further distances.

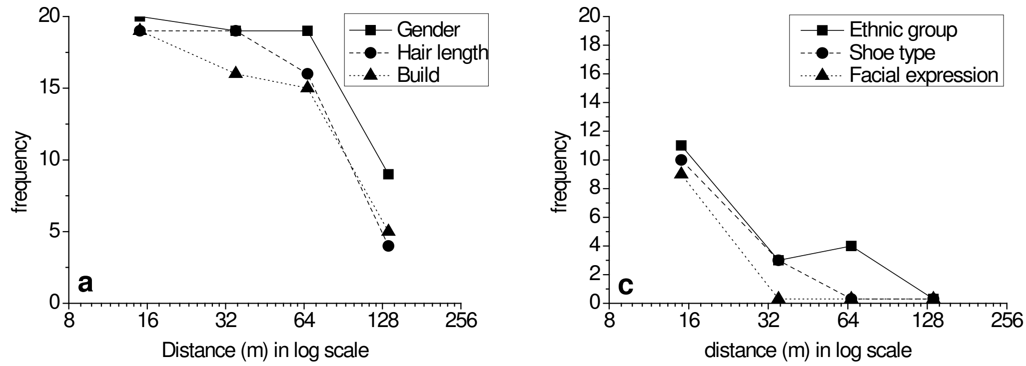

Figure 1 – Frequency by which features of target people were mentioned at different interpersonal distances (Yang and Fotios, 2012).

4 Judgements of Threat

The ability to recognize a face is perhaps not what matters most to people who are concerned about safety on the streets after dark. What we suggest does matter is the ability to recognise the intent of people approaching. In the current work we are exploring judgements of threatening intention using facial expression, body posture and gaze direction and hence how these judgements are effected by lighting.

Facial expressions provide perhaps the most effective means of communicating emotion (Etcoff and Magee, 1992; Chen and Chen, 2010). There is an interaction between facial expression and body posture: Meeren et al (2005) carried out experiments in which test participants were asked to make rapid judgements on compound images of the face and body in which the expressions of fear and angry were either matched or mismatched. Electrical brain activity was used as monitoring indicator. Their results indicate that observers judging a facial expression were strongly influenced by body language. Boyce and Gutkowski (1995) recognised the contribution of facial expression and body language to judgements of intent and thus to fear of crime. Ekman (1965) suggested that facial expression identifies the emotion while body cues indicate its intensity. He presented observers with photos of the subject's head only, body only and head and body together, and studied their ratings of various emotions in the subject. The results suggest that facial expression identifies the emotion while body cues indicate its intensity.

Looking at other people serves the two functions of observation and signalling. It is often used as a threat signal by animals as well as in certain situations by humans (Argyle et al., 1974, Ellsworth et al., 1972). Argyle and Dean (1965) discuss the appropriate level of friendliness for an encounter, which is maintained by the amount of mutual gaze among other things: if one of the subjects wants to make an encounter more intimate, he/she may look more, but if the other person does not approve of this increase in intimacy, he/she will not reciprocate and may see the increased gaze as an intrusion. Thus interpretation of intention may depend on both facial expression and gaze direction. Adams and Kleck (2003) conducted two studies to test whether direct and averted gaze would respectively facilitate the processing of approach-oriented and avoidance-oriented emotions. The results of participant's response latency and standard error on the judgements of corresponding expressions suggested that gaze direction and facial expression are combined in the processing of emotionally relevant facial information.

Fotios and Raynham (2011) suggested that intent might be investigated using faces exhibiting different expressions and asking for these to be categorised as either friendly or non-friendly. This would allow a variety of targets to be presented at a constant visual size, with controlled duration of observation, lit in different ways, in a random order.

An attempt to do this was reported by Fotios and Yang (2013). Twenty test participants were presented with a set of 48 images in random order, these being 24 facial expressions and 24 body postures, and asked to state whether or not the target would be considered threatening if encountered alone after dark. Targets were extracted from standard databases (Ebner et al, 2010; de Gelder and van den Stock, 2011) and presented on a series of cards, in a randomised order, with one target per card. The size of the targets were chosen to present the images at the visual size at which decisions would be made in real situations, 10 m for facial expression and 30 m for body posture. Participants were required to make rapid judgements and this was typically within 2s per image. All trials were carried out under daylight or office lighting, higher light levels than experienced under road lighting.

There are six universally recognised facial expressions: neutrality, sadness, disgust, fear, anger, and happiness (Etcoff and Magee, 1992). It was concluded that happy expressions tended to lead to consistent judgements of not-threat, angry expressions tended to lead to judgements of a threat but with less consistency that the happy expressions, but that the remaining expressions did not lead to consistent judgements of threat or not-threat. For body posture four recognisable emotions have been proposed: anger, fear, happiness, and sadness (de Gelder & Stock, 2011). As with facial expressions, the happy postures lead to consistent non-threat judgements, but the fear, sad and angry postures did not lead to consistent judgements (Fotios and Yang, 2013).

If judgements of the threat presented by a target are not consistent, this confounds investigation of the effects of lighting.

5 New Studies

Four experiments are being carried out from which to interpret how lighting may affect visual cues to inter-personal judgements:

- *Gaze direction.* The literature suggests that another person looking at you can be perceived to present a threat. This test will determine whether ability to recognise gaze direction (with variations in eye and/or head movement) is affected by lighting at low illuminances.
- *Recognition of facial expressions and body postures*. Pilot studies did not suggest that judgements of intent based on the standard facial expressions and body postures are consistent, exhibiting within-subject and between-subject variance. Thus initially the ability to recognise the emotions intended by standard expressions/postures at low light levels will be examined. Databases of the standard expressions and postures have been validated under good lighting conditions, i.e. high luminances, but not the low luminances typical of road lighting.
- *Judgement of threat based on facial expression and body posture*. While this task is the more directly relevant to investigation of inter-personal judgements, pilot studies reveal inconsistent results. A further problem is that there is no right answer – an angry expression does not lead with certainty to a threat decision and this may add noise to the data.
- *Facial recognition*. For benchmarking with past studies of lighting, a fourth test investigates facial recognition. In an attempt to develop the methodology used in past studies this test uses target faces of constant size, limited observation duration, and more precise recognition criterion.

Target images are photographs drawn from standard databases, these presented on a non-self-illuminated display screen (i.e. an e-reader). A non- self-illuminated screen was sought to avoid the confound of screen light upon ambient light. The targets are presented for 1 s, the fixation suggested in eye tracking studies of pedestrians. This study examines the effects of the level and spectrum of lighting, using three vertical illuminances on the target faces (approximately 0.2, 2.0 and 20 lux) and two types of lamp representing spectra of poor and good colour quality (HPS and MH).Test participants were drawn from younger and older age groups.

6 Method

Target stimuli, colour photographs of faces or bodies, were presented on a non-self-illuminated screen (Pixel Qi® PQ3Qi-01, 10.1'') having a resolution of 1024 × 600. The non-self-illuminated status is achieved by switching off the back light of the screen. It was subsequently found that in this status, at the low light levels of the current study, the target images were apparently grey scale.

Target images were photographs of actors expressing a range of facial expressions, body postures and gaze directions, and these were obtained with permission from three databases. The FACES database is a set of images of naturalistic faces of 171 younger, middle-aged and older women and men, displaying each of six facial expressions: anger, disgust, fear, happiness, neutrality and sadness (Ebner et al., 2010). Twenty four images were used, these being six expressions from each of four targets: a young male, a young female, an old male and an old female. The BEAST database comprises 254 whole body postures from 46 actors expressing four emotions; anger, fear, happiness, and sadness (de Gelder and van den Stock, 2011). Sixteen images were selected, these being four postures from four target people, two males and two females. Note that in these images the target faces are covered by neutral shading. Gaze direction targets were selected from the head pose and gaze database developed by Institute of Neural Information Processing University of Ulm (Weidenbacher et al., 2007). Sixteen images of four target people were used, these being two males and two females with one male and one female wearing glasses. For each target person there were four combinations of head pose and gaze direction: straight or rotated head position and direct or averted gaze.

The screen was observed inside a test booth (Figure 2), this designed to permit changes in luminance (by adjustment of an iris) and spectral power distribution (by changing lamp type) with negligible change in spatial distribution. The screen was placed on the floor of the booth and lit from overhead. It was observed from a distance of 0.65 and this was maintained using a chin rest with forehead restraint.

The sizes of target images were manipulated to represent different observation distances. Following discussion above of comfort distance, and with limitations imposed by the screen size, the simulated distances were 4 m, 10 m and 15 m for facial expression; 2 m, 4 m and 10 m for gaze direction; 10 m, 30 m and 135 m for body postures. According to the results of pilot studies, these target sizes should also approximately bracket the range of performance from chance level to a good level.

Six lighting conditions were used. There were two types of lamp, high pressure sodium (HPS; 2000K, S/P= 0.57, Ra = 25 Ra) and a metal halide lamp (MH: 4200K, S/P = 1.77, Ra = 92). Three light levels were used. These were approximately 0.2, 2.0 and 20 lux, chosen to bracket the range of light levels expected in residential streets in the UK: the two log unit range was chosen to have reasonable expectation of an effect of light level. Each lamp was adjusted to present a target luminance on the screen of 0.01 cd/m^2, 0.1 cd/m^2 and 1 cd/m^2.

7 Procedure

Visual acuity was examined using a Landolt ring test and normal colour vision was confirmed using the Ishihara test, these observed under a D65 source. Test participants were seated facing the screen. Each trial started with 20 minute for adaptation to the low light level.

A series of practise trials were used to present and confirm understanding of the response options. Responses were given using a button box, with one button for each of the available responses. The responses were emotions (anger, disgust, fear, happiness, neutrality and sadness) for the facial expression targets, similarly (anger, fear, happiness, and sadness) for the body posture targets, and gaze toward or away from the observer (test participant) for the gaze direction targets. Each target was presented for 1000 ms, this being chosen to simulate the rapid observation of an unknown approaching person expected in real situations, with no time limit for input of the subsequent response.

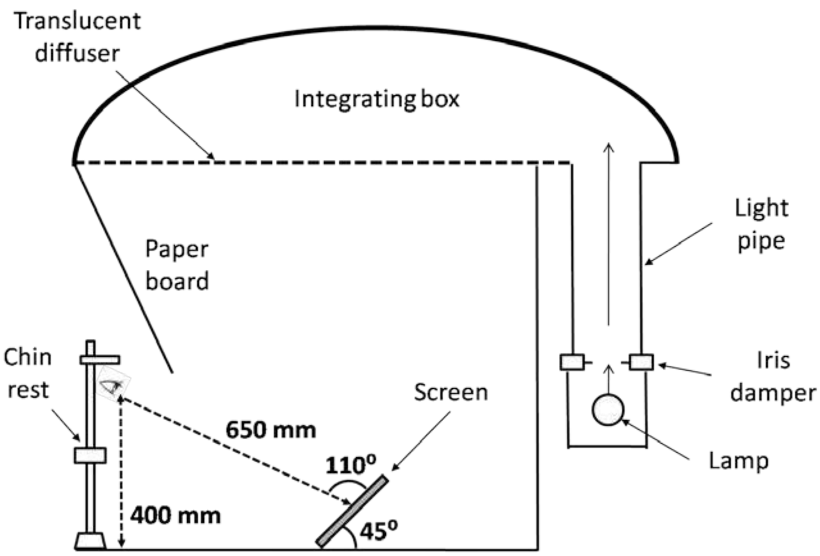

Figure 2 – Section through apparatus used to observe target faces/bodies under different light settings.

The sequence in which the three tasks (categorical perception of facial expression, body posture and gaze direction) were used was counterbalanced, and within each task the images with different sizes, and emotions or gaze directions, were mixed and presented in a semi-random order.

8 Results

The aim is to use 30 test participants. To date, ten have completed the gaze direction trial and judgements of emotion from facial expression and body posture (1 and 2 above).These were recruited from staff and students at the University of Sheffield and were paid a small fee for their contribution. Seven were male and three were female; they were drawn from European, Middle East and Asian populations; eight were young (aged 18-40 years old) and two were in the 40-65 age group. These initial results are shown in Figures 3-5.

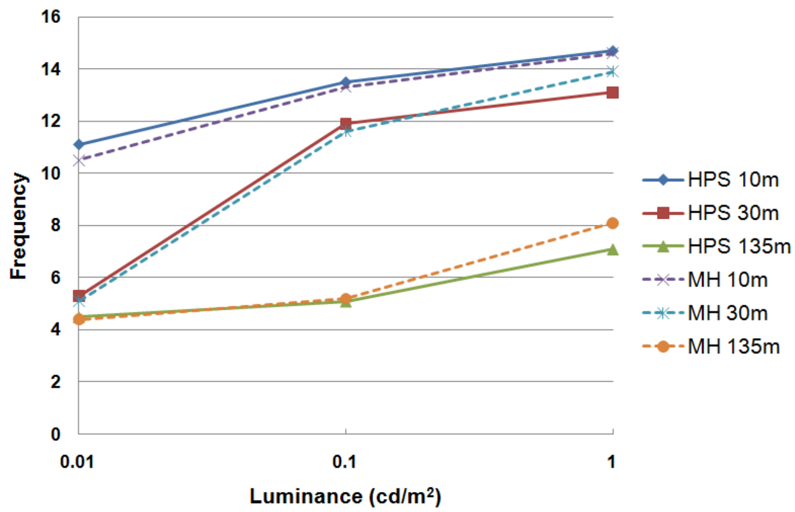

Figure 3 – Average frequency for correctly identifying emotion from observation of the body posturetargets. There were four possible emotions and four target people: maximum frequency = 16, chance frequency = 4.

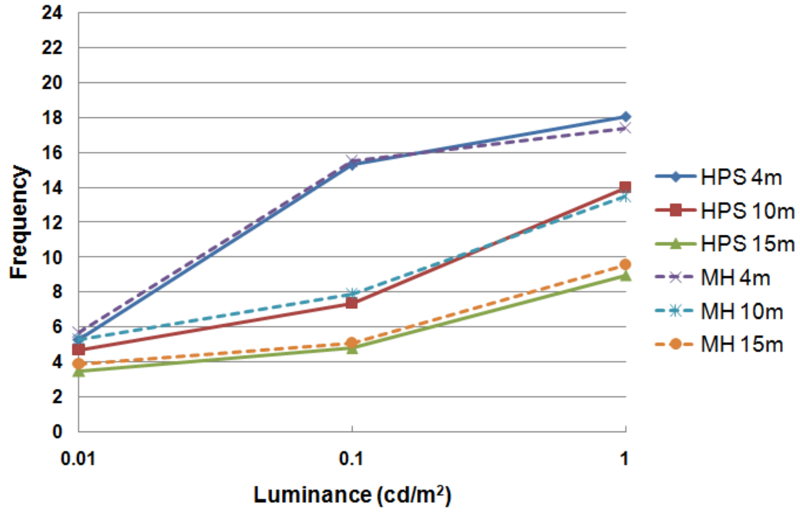

Figure 4 – Average frequency for correctly identifying emotion from observation of the facial expression targets. There were six possible emotions and four target people: maximum frequency = 24, chance frequency = 4.

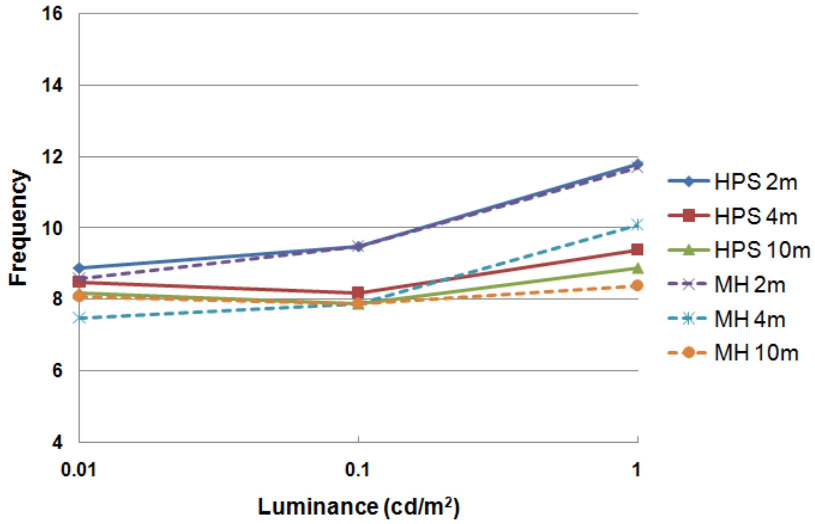

Figure 5 – Average frequency for correctly identifying gaze direction from observation of the target faces. There were four combinations of head and eye orientation and four target people: maximum frequency = 16, chance frequency = 8.

The visual tasks were achromatic and were centrally fixated: as expected, there is no apparent difference in performance between the HPS and MH lamps.

As luminance increases, there is an apparent increase in probability of identifying emotion exhibited by facial expression or body posture; for gaze direction, luminances of 0.01 and 0.1 cd/m^2 lead to performance at the chance level, and a luminance of 1.0 leads to just above chance level performance. At 0.01 cd/m^2 only body postures at a distance of 10m can be identified at a performance level above chance.

Shorter distances lead to increased probability of identifying emotion exhibited by facial expression or body posture: this may be as expected due to the larger visual size subtended.

For gaze direction, at low light levels (0.01 and 0.1 cd/m^2) there is no apparent difference between the three simulated distances: for the higher light level (1.0 cd/m^2) there is a higher probability for detecting gaze direction of the closer targets than the distant targets.

If identification of gaze direction is important, these data suggest a need for target luminances of at least 1.0 cd/m^2 to ensure probability of correct identification above the chance level. The facial expression and body posture data suggest a plateau-escarpment relationship, and the knee in these curves provides one estimate of minimum light level.

The maximum identification probabilities found in the current data (75% for facial expression and 92% for body posture) approach those exhibited (81.3% for facial expression (Ebner et al, 2010) and 92.6% for body posture (de Gelder and van den Stock, 2011)) when the databases were validated under good lighting conditions with longer exposure durations (4 s for body, unlimited for face). For facial expressions at 4 m this is 0.1 cd/m^2 increasing to 1.0 cd/m^2 for identification at 10m. For body posture, a larger visual target than facial expression, all three luminances yield close to plateau performance at 10m, but for identification at 30 m a minimum luminance of 0.1 cd/m^2 is required.

These observations are drawn from experiments with only ten test participants and will be re-examined following completion of the larger sample. There is also a need to repeat these trials using colour targets: this may reveal differences in performance between lamps and may affect judgements of performance thresholds. It is apparent that using these data to suggest design light levels requires further discussion as to which task(s) is the more critical and at which distance the critical task needs to be carried out.

9 Conclusion

This article discusses interpersonal judgements made between pedestrians after dark and in particular that judgements of intent are needed in addition to judgements of identity. The current study uses judgements of emotion from facial expression and body posture, and judgements of gaze direction, to evaluate the influence of lighting on perceived intent. This work includes investigation of interpersonal distances – how far away we desire other people to be when making judgements of intent.

An experiment has been carried out in which forced choice judgements of emotion or gaze direction are sought after 1000 ms exposure using combinations of luminance and interpersonal distance. Initial results for judgements of emotion from facial expression suggest a minimum luminance on the face of 0.1 cd/m^2 if facial expressions are to be recognised at 4 m, increasing to 1.0 cd/m^2 for identification at 10m.

Acknowledgement

This work was carried out through funding received from the Engineering and Physical Sciences Research Council (EPSRC) grant number EP/H050817.

References

ADAMS, R. & KLECK, R. 2003. Perceived gaze direction and the processing of facial displays of emotion. Psychological Science, 14, 644-647.

ADAMS, L. & Zuckerman, D. 1991. The Effect of Lighting Conditions on Personal Space Requirements. Journal of general psychology, 118 (4), 335-340.

ARGYLE, M. & DEAN, J. 1965. Eye-contact, distance and affiliation. Sociometry, 28, 289-304.

ARGYLE, M., LEFEBVRE, L. & COOK, M. 1974. The meaning of five patterns of gaze. European Journal of Social Psychology, 4, 125-136.

BOYCE, P., & GUTKOWSKI, J. 1995. The if, why and what of street lighting and street crime: A review. Lighting Research and Technology, 27(2), 103-112.

CAMINADA, J. and VAN BOMMEL, W. 1980. New Lighting Considerations for Residential Areas. International Lighting Review, 3, 69-75.

CHEN, M. and CHEN, C. 2010. The contribution of the upper and lower face in happy and sad facial expression classification, Vision Research, 50, 1814-1823.

CUTTING, J. & VISHTON, P. 1995. Perceiving layout and knowing distances: The integration, relative potency, and contextual use of different information about depth. Perception of Space and Motion, 5, 69-117.

EBNER, N., RIEDIGER, M. & LINDENBERGER, U. 2010. FACES—A database of facial expressions in young, middle-aged, and older women and men: Development and validation. Behavior Research Methods, 42, 351-362.

EKMAN, P. 1965. Differential communication of affect by head and body cues. Journal of Personality and Social Psychology, 2, 726-735.

ELLSWORTH, P., CARLSMITH, J. & HENSON, A. 1972. The stare as a stimulus to flight in human subjects: A series of field experiments. Journal of Personality and Social Psychology, 21, 302

ETCOFF, N. & MAGEE, J.1992. Categorical perception of facial expressions, Cognition, 44, 227-240.

FOTIOS, S. & GOODMAN, T. 2012. Proposed UK Guidance for Lighting in Residential Roads. Lighting Research & Technology, 44(1), 69-83.

FOTIOS, S. & RAYNHAM, P. 2011. Correspondence: Lighting for pedestrians: Is facial recognition what matters? Lighting Research & Technology, 43(1), 129-130.

FOTIOS, S. & YANG, B. 2013. Exploring Interpersonal Judgements between Pedestrians. Lux Pacifica, Bangkok, March 2013.

FUJIYAMA, T., CHILDS, C., BOAMPONG, D. & TYLER, N. 2005. Investigation of Lighting Levels for Pedestrians - Some questions about lighting levels of current lighting standards. London: Centre for Transport Studies

DE GELDER, B. & VAN DEN STOCK, J. 2011. The Bodily Expressive Action Stimulus Test (BEAST): Construction and validation of a stimulus basis for measuring perception of whole body expression of emotions, Frontiers in Psychology, 2, 181.

HANCOCK, P., BRUCE, V. & BURTON, A. 2000. Recognition of unfamiliar faces, Trends in Cognitive Sciences, 4(9), 330-337.

HALL, E. 1969. The Hidden Dimension. New York: Anchor Books, p123-124.

HAYDUK, L. 1978. Personal space: An evaluative and orienting overview. Psychological Bulletin, 85(1), 117-134.

INSTITUTION OF LIGHTING PROFESSIONALS (ILP). Professional Lighting Guide PLG03: 2012. Lighting for Subsidiary Roads: Using white light sources to balance energy efficiency and visual amenity. Rugby; ILP.

MEEREN, H., VAN HEIJNSBERGEN, C. & DE GELDER, B. 2005. Rapid Perceptual Integration of Facial Expression and Emotional Body Language. Proceedings of the National Academy of Sciences of the United States of America, 102, 16518-16523.

METRAC: The Metropolitan Toronto Action Committee on Violence Against Women and Children. 1989. Womens' safety audit guide. (Original report not located). Cited by LUYMES,

D. & TAMMINGA, K. 1995. Integrating public safety and use into planning urban greenways. Landscape and Urban Planning, 33, 391-400.

RAYNHAM, P. & SAKSVIKRØNNIN, T. 2003. White Light and Facial Recognition, The Lighting Journal, 68(1), 29-33.

SIMONS, R., HARGROVES, R., POLLARD, N. & SIMPSON, M. 1987. Lighting criteria for residential roads and areas. CIE, Venice, 274-277.

SOBEL, R., LILLITH, N. 1975. Determinants of Nonstationary Personal Space Invasion. The Journal of Social Psychology.; 97 (1): 39-45.

TOWNSHEND, T. Safer City Centres: The Role of Public Lighting. *In*: Oc T, Tiesdell S, editors. 1997. Safer City Centres: Reviving the Public Realm. London: Paul Chapman Publishing Ltd, p119-129.

WEIDENBACHER, U., LAYHER, G., STRAUSS, P. & NEUMANN, H. 2007. A comprehensive head pose and gaze database. In: 3rd IET International Conference on Intelligent Environments, Ulm, Germany, 455-458.

YANG, B. & FOTIOS, S. 2012. Inter-personal Judgements for Pedestrians at Night: Exploring Information Perceived at Different Distances. Ingineria Iluminatului, 14(1), 31-44.