Using eye tracking in lighting research

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Subjective assessments

To investigate the effect of changes in lighting conditions for pedestrians we first need to know what they need lighting for, e.g. where they are looking.

This could be established by asking people, e.g.

When you are walking along a footpath, where do you tend to look?

Stated preference

rather than

revealed preference

Subjective assessments

Similarly we might want to establish how changes in light affect behaviour:

How safe do you feel when walking?

1	2	3	4	5	6	7
Very safe						Very unsafe

Quantitative subjective assessments are almost always ***biased****, sometimes* ***completely misleading***

Poulton, EC. British Journal of Psychology 1977; 68: 409-425

Eye Tracking

Land 2006

- "*the eyes are proactive, typically seeking out the information required in the second before each act commences, although occasional 'look ahead' fixations are made to establish the locations of objects for use further into the future*."
- Eye movements are not simply reflex actions related to the scene but to 'top down' instruction from the brain: eye movements are strategic.

- *When crossing level ground, walkers rarely need to look at where they are going to step safely. However, in more difficult terrain they tend to fixate the location of their future footfalls*

  (see also Patla & Vickers 2003, Marigold & Patla 2007)

Eye Tracking

Eye movements

- Saccades: the fast movements that redirect the eye to a new part of the surroundings
- Fixations: the intervals between saccades in which gaze is held almost stationary

Measurement of eye movement

- Gaze direction
- Frequency and duration of fixations
- Speed of movement between fixations
- (Pupil size)

Haptic contact lens

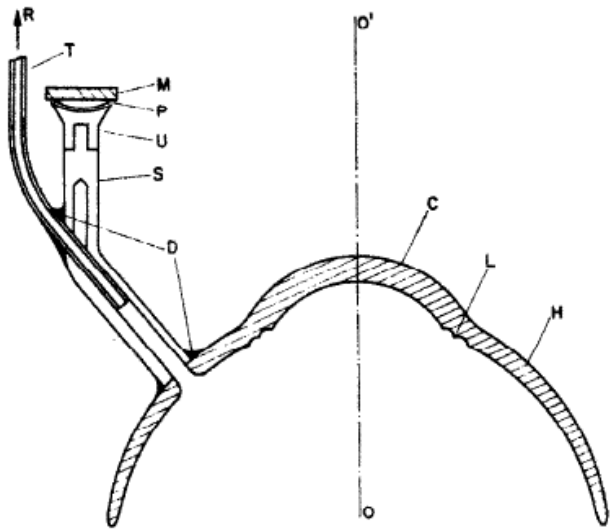

FIG. 1. Haptic contact lens with stalk/mirror unit attached. 0–0¹ optical axis; R to suction reservoir; T polyethylene tube $\frac{1}{16}$ in. o.d.; M flat front surface mirror; P grease pad (M may be moved laterally on P for collimation purposes); S stalk $\frac{1}{4}$ in. o.d., drilled bore $\frac{1}{16}$ in. i.d., to allow entry of suction tube T; C corneal section of lens; L transcurves over limbus; H haptic section; D Durofix seals; U cup.

Boyce PR.

An investigation of eye movements during fixation and tracking tasks.

PhD thesis.

University of Reading. Department of Physics. 1965

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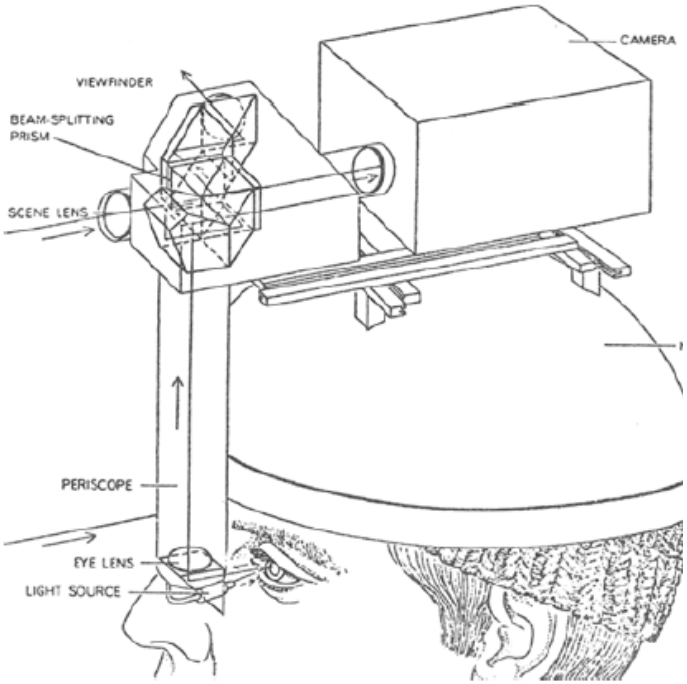
Mobile eye tracking



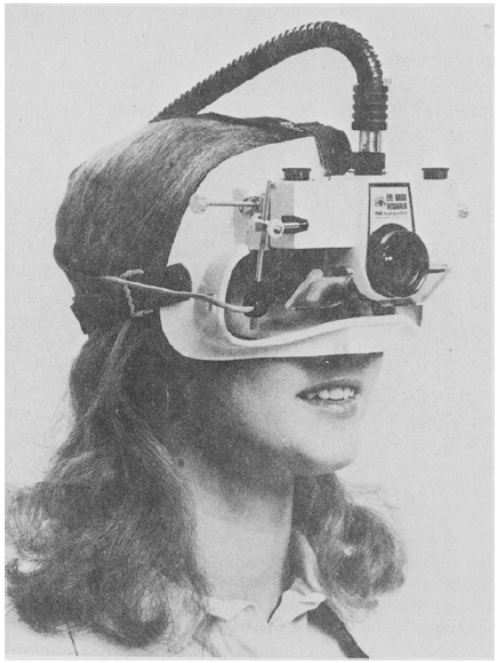


Figure 8. Head-mounted corneal reflex illumination, viewing, and combining optics (Courtesy of Instrumentation Marketing Corporation).

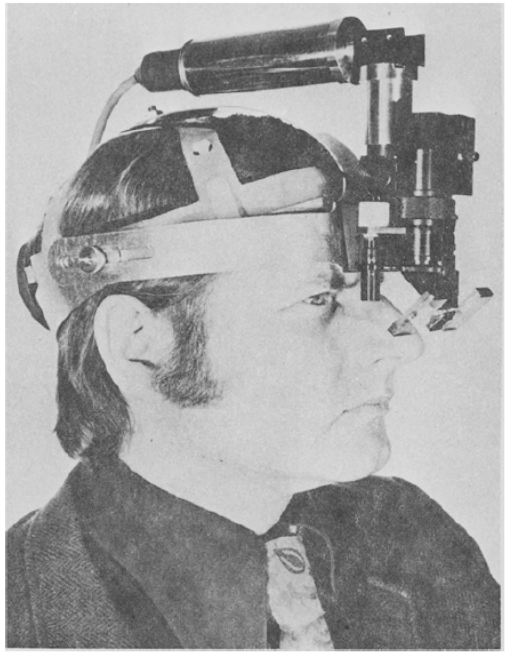


Figure 9. Head-mounted corneal reflex illumination, viewing and combining optics (courtesy of Instrumentation Marketing Corporation).

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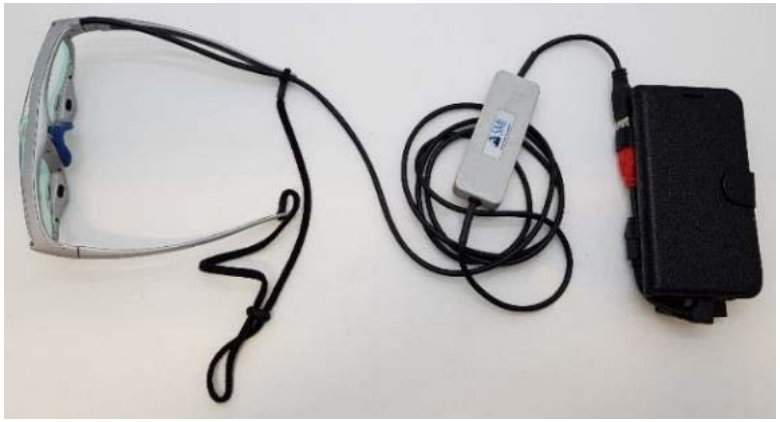
Mobile eye tracking

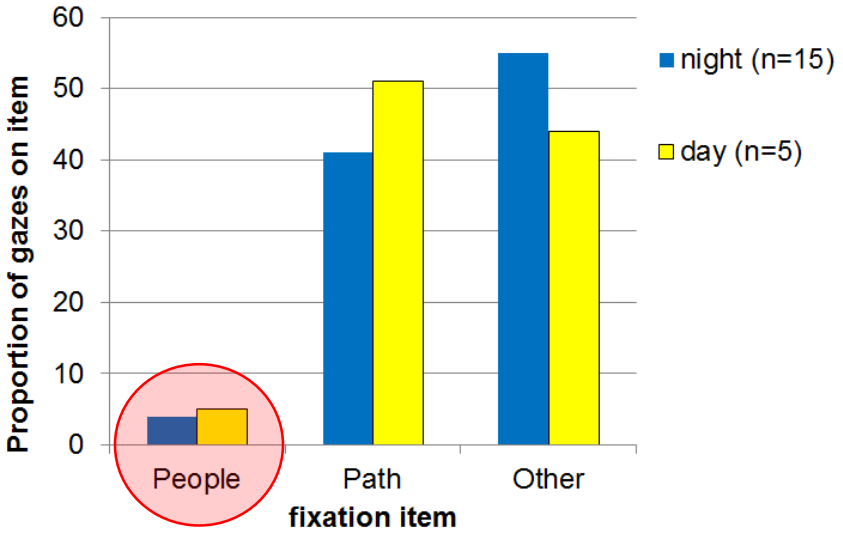


What do pedestrians need to see?

Use eye tracking to identify the objects they fixate

Outdoor Eye-Tracking Studies

Foulsham, Walker & Kingstone, 2011
5-10 mins, outdoor, daytime, N=14



Davoudian & Raynham, 2012
690 m path along residential roads

Fixation On Pedestrians	Foulsham et al. 2011	Davoudian & Raynham 2012
Proportion of all fixations	21%	3%
Probability of fixation	83%	100%

Does not suggest pedestrians to be important

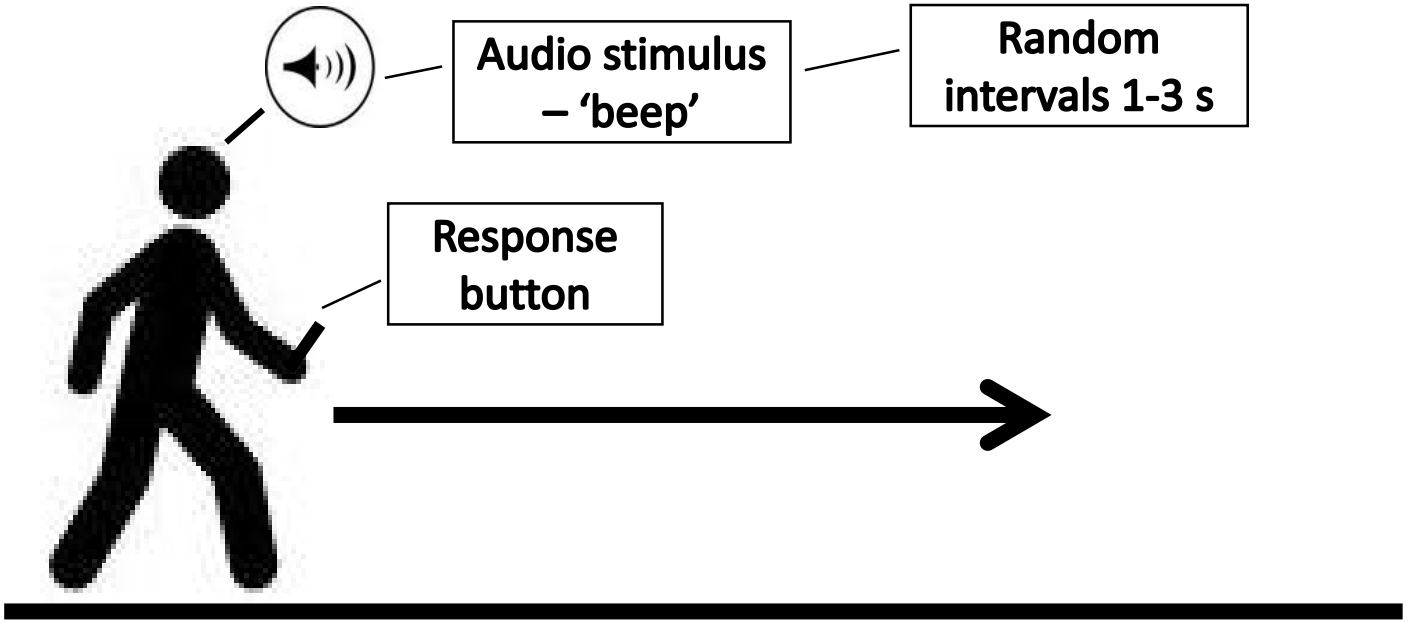
Pedestrians are important

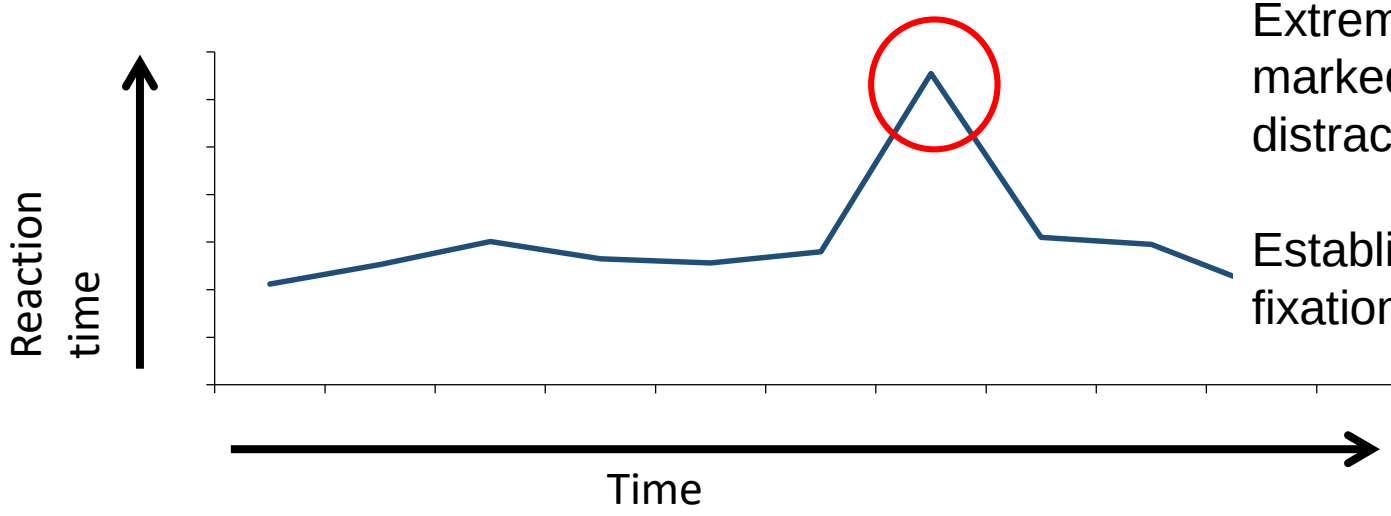
Outdoor Eye-Tracking Studies: Limitations

Uncontrolled frequency of occurrence

Importance to the task of safe walking not established

Dual Task Approach





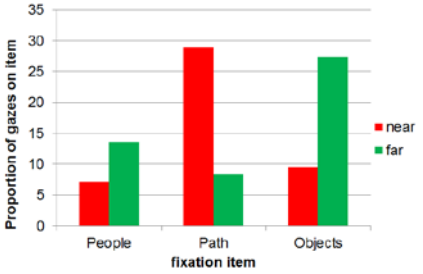
Extremely slow reactions marked moments of distraction.

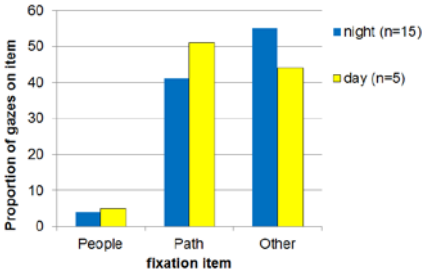
Establish object of fixation at these moment

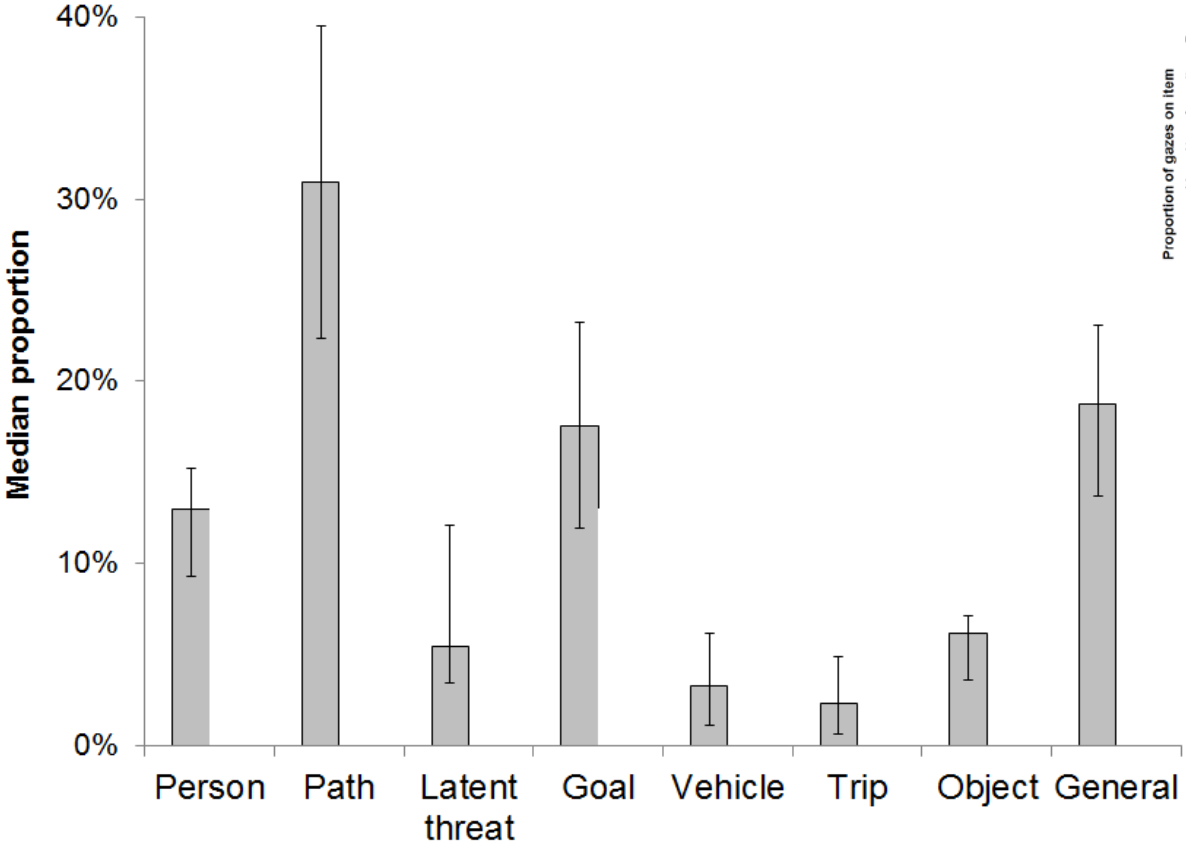
What do pedestrians need to see?

Use eye tracking to identify the objects they fixate **at critical moments.**

Results: ALL fixations



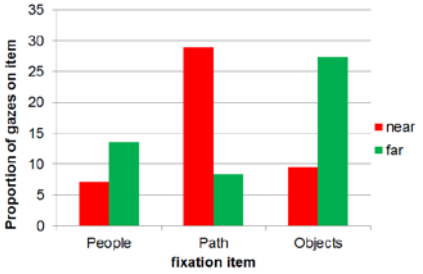


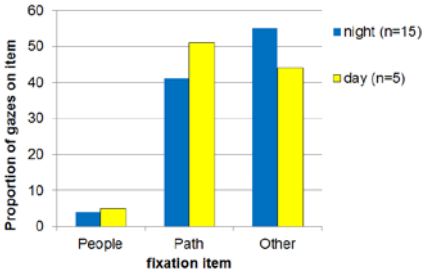


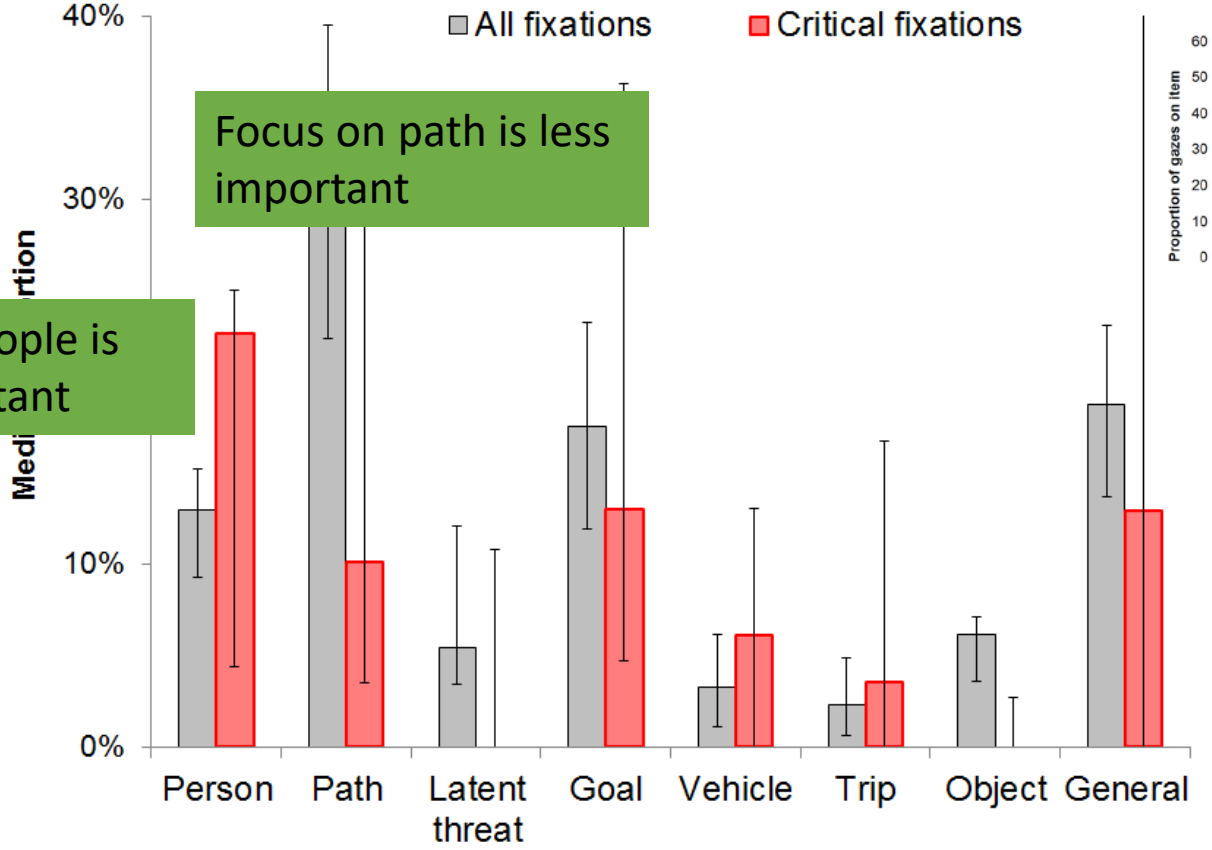
Median proportions: Error bars represent interquartile range.
After-dark trials.

Fotios et al 2015a, 2015b

Results: CRITICAL fixations







Focus on path is less important

Focus on people is more important

Median proportions: Error bars represent interquartile range.
After-dark trials.

Fotios et al 2015a, 2015b

How do we evaluate other people?

Previous studies have investigated facial identity recognition and facial emotion (expression) recognition.

Is the face the most important cue? *(Fotios, Hamoodh & Clanton 2019)*

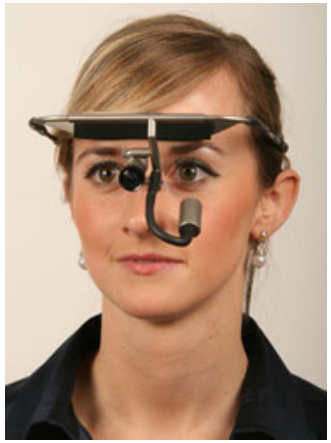
- *What aspect is fixated first / most frequently / for longest duration?*

How safe do you feel?

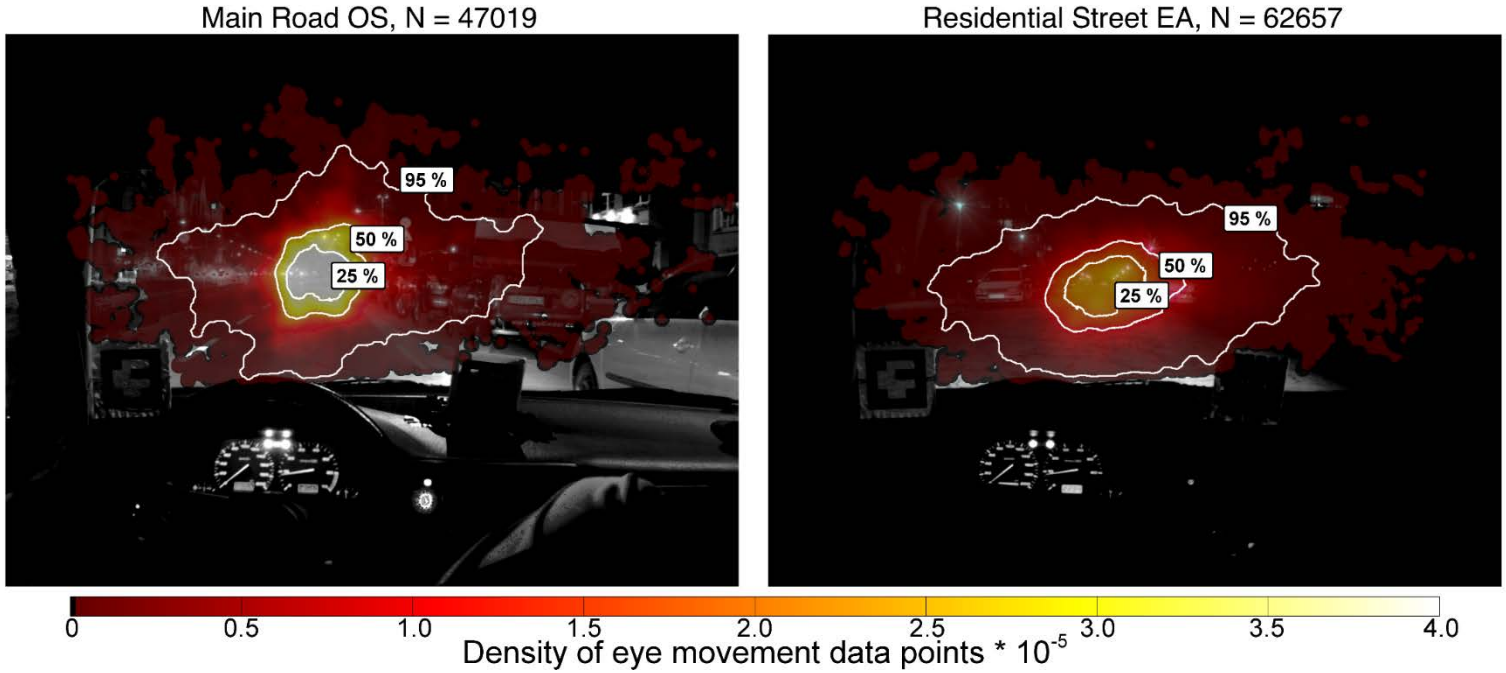
Planned comparison of eye movement data in locations representing a range of lighting conditions and anticipated levels of reassurance:

- *Pupil size*
- *Saccade speed*

Using driver's gaze behaviour to estimate adaptation luminance



Winter, Fotios and Völker 2017, 2019



Main road

Residential road

Summary

Mobile eye tracking allows the recording of eye movement during practical tasks.

With caution in interpretation, this can be used to inform questions about the benefits of lighting for people.

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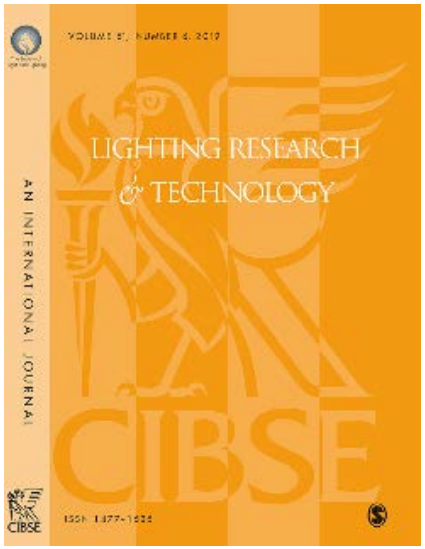

BRIGHT LIGHTS