THE FUTURE OF TRANSPORT

"Stop me when I get to 23"

(or

A Focus on the Weakest Link

in the Driven Environment)

July 2020

Mark Hill – Expert Witness Group

Very briefly;

- What am I doing here?

  Collision Investigator;

  Focus on human performance in the driven environment;

  - Driving, Riding, Pedestrian behaviour
  - Lecturer in Human Factors in the driven environment

- My background

  Sussex Police;

  - Roads Policing (Traffic) since 1995
  - Forensic Collision Investigator since 2004
  - TRL, Expert Witness Group since 2014

Agenda

- Why I am presenting?
- Human factors – what its about
- Questions at the end

However, feel free to ‘unmute’ and ask during the presentation (but please remember to ‘re-mute’ afterward!)

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Additional TRL domain experts in roads, signaling, biomechanics, crashworthiness

At the Transport Research Laboratory

Active Human Factors Group.

Pre-eminent in numerous aspects of HF in road use including;

- Mobile phone usage whilst driving
- Conversations in cars
- Pedestrian injury taxonomy relating to speed
- Driver distraction (legitimised and non-legitimised)
- Mirror sight-line field of view
- Fatigue and sleepiness
- Driver demographic and risk potential

All of which add insight and support to collision investigation.

Human Factors

"We are just too young to drive."

Through evolution our brain has developed to allow us to design highly complex machines which enable us to exceed <u>our</u> design speed.

The question remains, have drivers have overtaken evolution?

At the end of this presentation I hope to have:-

- Illustrated some of the fallibilities in the operator/vehicle relationship
- Given an overview of sight, being perhaps the principal dependent sense in road use to be considered in investigations
- Explored its significance to the other major human factors in relation to using the roads

Human Factors in the driven environment

- Where to start;

Human Factors in Road Collision Investigation

Sight
Multi-tasking
Mobility of the head/neck
Reaction speed
Perception Response Time
Distraction – Intrinsic and Extrinsic
Fatigue paradigm
Concentration Span (≈ 45 to 60 minutes)
Sleepiness
Cognitive Processing
Cognitive Salience – what we are thinking of
Risk Acceptance – Risk Homeostasis/allostasis

Home from Home
Personal Space
Stereotyping
Pariedolia

Psychology Research –
Cognitive,
Occupational,
Neuro,
Social

This list is not exhaustive

Three of the most significant factors

- Sight – capabilities and limitations
- Perception Response Time
- Distraction

All three are interlinked and usually interwoven with other Human Factors

Man in an alien environment

Physiological incompatibility

Usain Bolt – 100m in 9.58 s, or 10.44 ms^1, or 23.55 mph

Cheetah – authenticated in excess of 26.84 ms^1, or 60 mph

Mitigation Design

- Engineering solutions by strengthening vehicle superstructure
- Occupant restraint – seat belts
- Energy absorption – crumple zones
- Deceleration force amelioration – Safety restraint systems
- Pedestrian safety systems – 'Citysafe' © Volvo Cars

Safety features

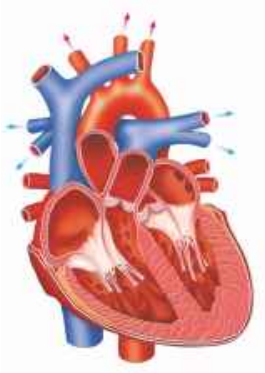
Just be sure of what your vehicle is equipped with and, like the airbag – something we buy but hope never to see – don't drive in false security!

Geared for Speed by Design

To begin at the beginning

Before considering sight function

Bellows



Pump

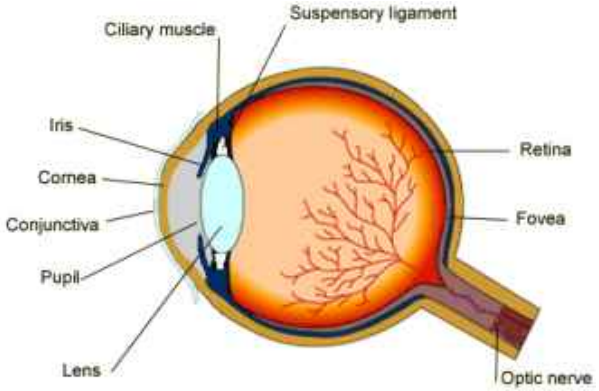
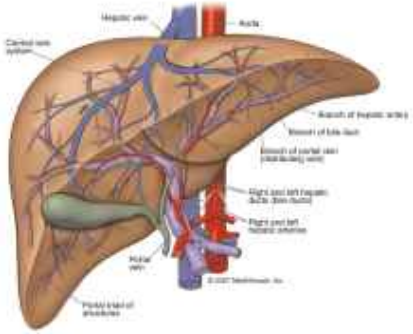


Photo-voltaic unit



Chemistry lab

Filter

Design Weakness

Two aspects to driving incompatibility

Physiological

✓ **Usually structurally sound for speed in excess of 28 mph**

X If it goes wrong. The skeleton is adequate for housing and protecting our vital organs at low speed (low deceleration), but is not cushioned to protect them at high speed (high deceleration) The organs bounce and stretch inside the skeleton

Psychological

Brain processing speed is adequate for necessary functions – i.e. reactions, data processing - for our maximum evolutionary speed and tasks, but is ill-suited to typically significantly higher speeds of driving

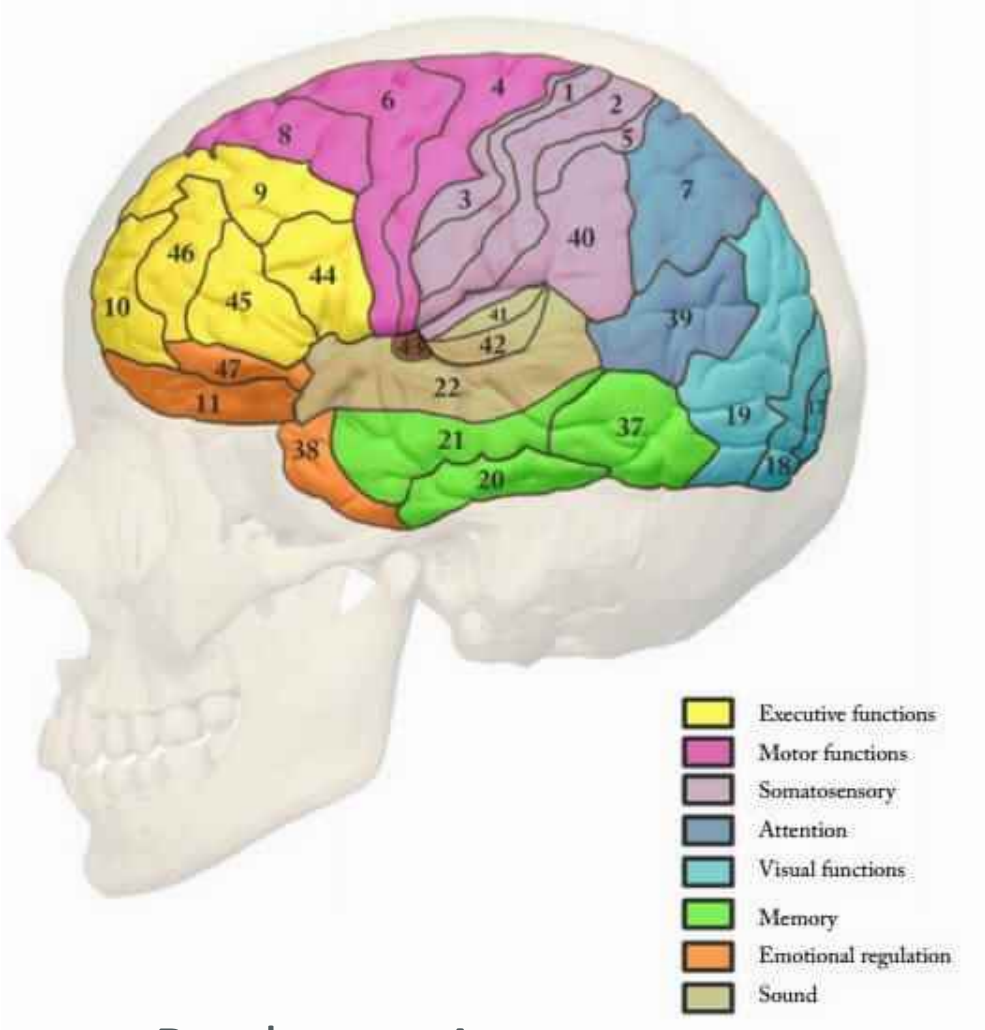
How it can go so wrong

To begin at the beginning

Where it all happens

Korbinian Brodmann (1909) –

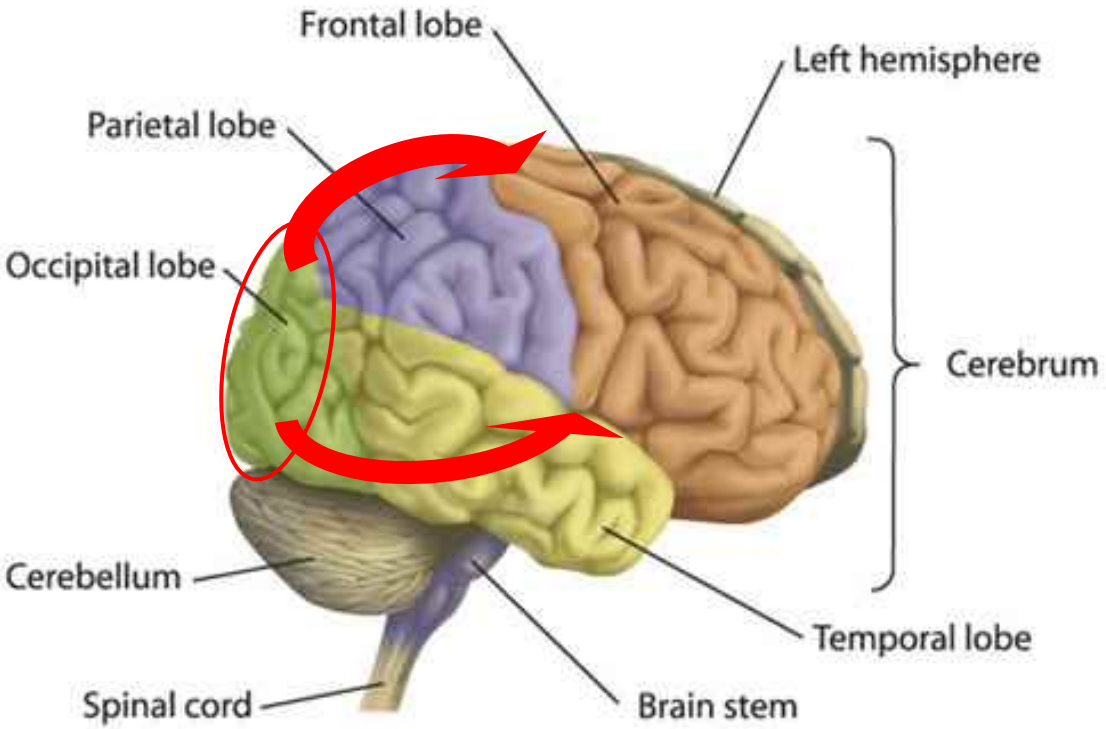
- Mapped histology to brain function
- Defined 52 areas and established core function and higher processing areas
- Sight initially received and processed in areas 17-19
- Image attribution and context processing in area 23 (≈ behind 41, 42, 45)
- Action directed from area 4 and lesser others



Brodmann Areas

To begin at the beginning

Before considering sight function



Electronic control unit

Eye/Brain correlation

Basic traits of the eye and cognitive interpretation of data

- First view of an object is to establish the outline – direction of travel, toward, or away, by size assimilation
- Detail focus toward the centre of the object – another person, toward the face, utilising the 5° (foveal) field of focus

Why? Expression generally gives the first indication of intention – threat or non-threat – 'Pareidolia'

Sight

- Retina – photo-receptive screen which generates electrical impulses
- Human eye ≈ 150 mega pixels – ‘resolution’
- Data collection organ – not a camera. Just the messenger
- Limited by; lighting levels, contrast graduation, visual textures, and in data processing, in the brain
- Object identification
- Decision making

Sight

- Saccadic fixation and dwell – rapid snapshots, even when focussed on small detail
- ALL data sent to brain – occipital lobe processes the data and filters out that which is not immediately relevant to the task in hand (Why do we feel tried after a train journey?)
- From experience the brain develops schemata, or templates, for speedier processing of similar events in the future

Sight – Marr's construct

- Impulses to brain (visual cortex – Brodmann 17 - 19) for initial interpretation/processing. Initial primal sketch, 2½D, then 3D model

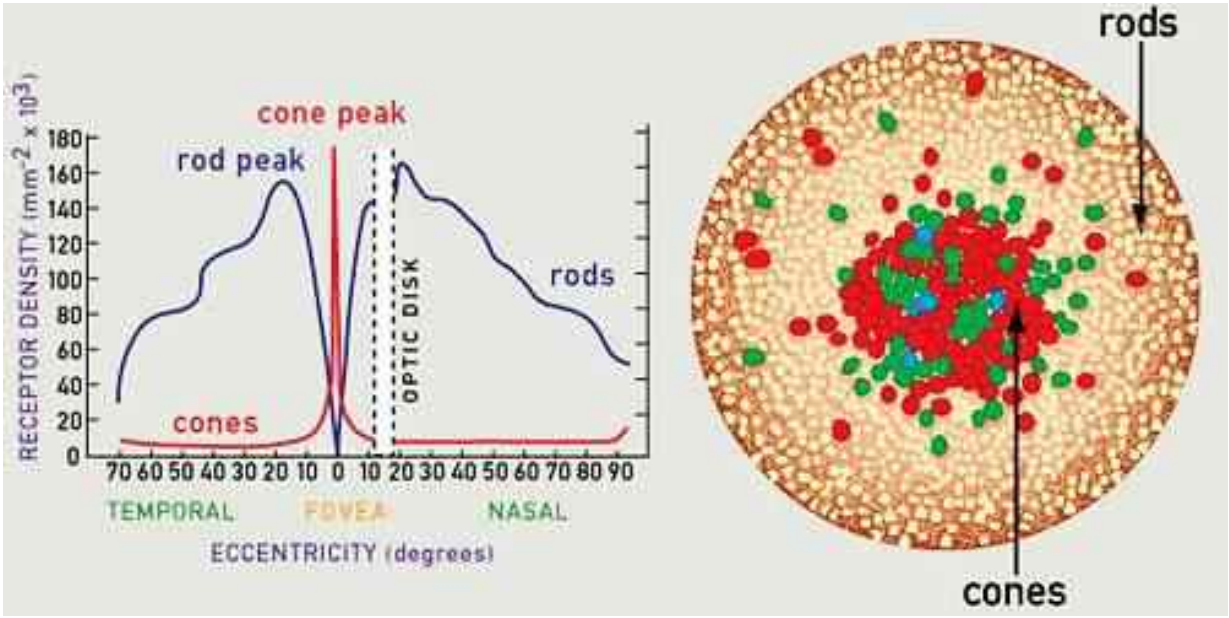
- Object identification in context into parietio-frontal and posterior cingulate areas (Brodmann 23) – Long -term memory, schema/heuristics, expectancy

- Decision making – whether/what action is required

The devil is in the detail

- Rods ≈ 120 million. Black & white – mainly contrast, texture, motion and light stimulus. Good scotopic. Not in fovea.

  Mostly outside of central FOV.
- Cones ≈ 6 million. Colour, three types – concentrated around central FOV. High resolution, detail. Good photopic and mesopic (daytime and street-lit).

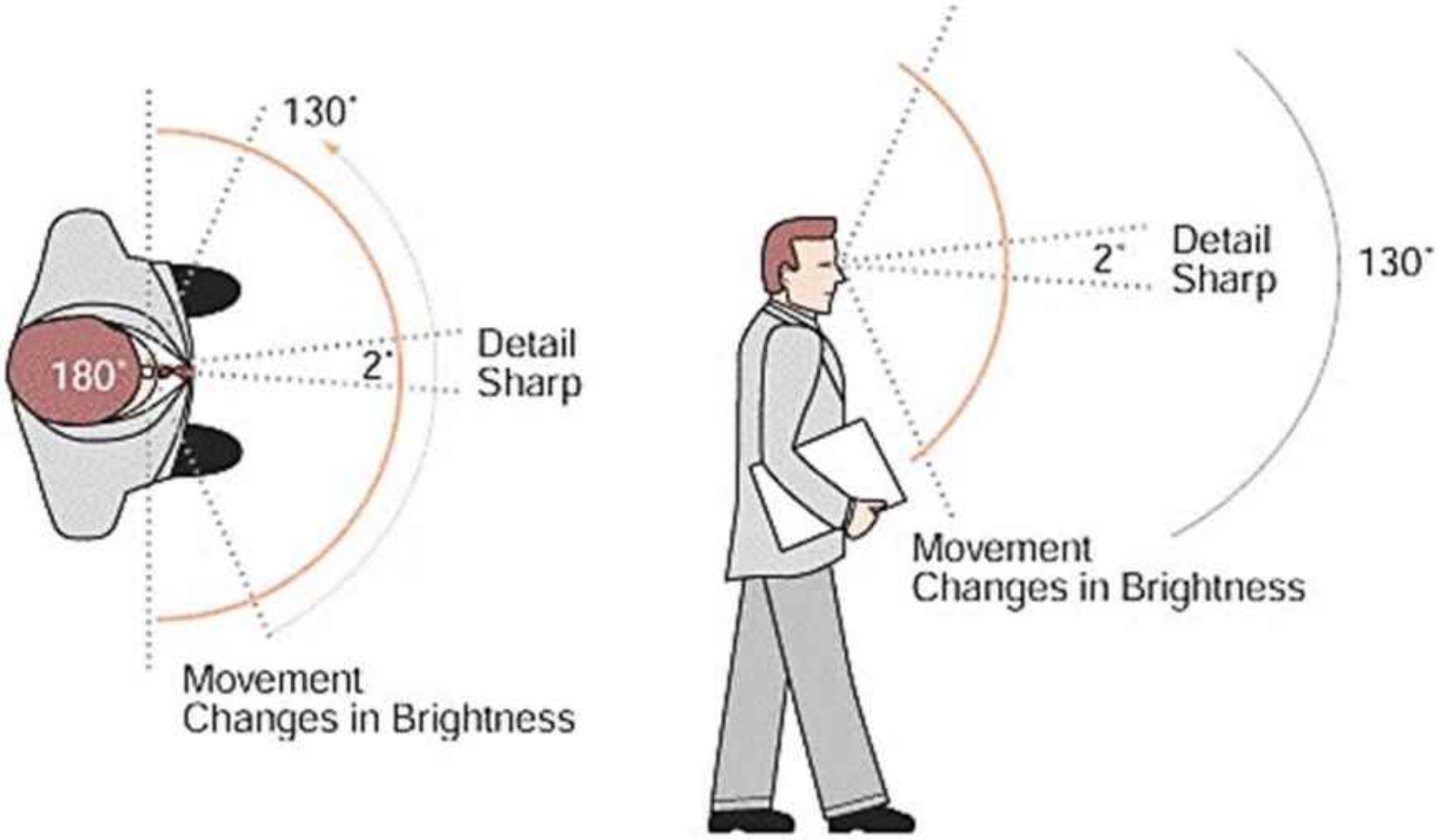


"*There to be seen*", or within the available field of view – at the material time?

- 'Legitimised distraction' – a matter for the Courts – required to keep a "proper lookout"
- Effective field of view ≈ 200°binocularly
- Periphery requires stronger movement and/or contrast stimulus for detection
- Head-turn required for fixation and gaze beyond 20°of the central sight-line (FFOV)
- Time taken for mechanical head-turn adds to gaze dwell and cognitive processing time PRIOR to decision on action and commencement . Accumulative with HGVs – cognitive lag

Foveal Field of View ≈ 2° to 5°

Fields of View



Pareidolia – Reading the tea leaves

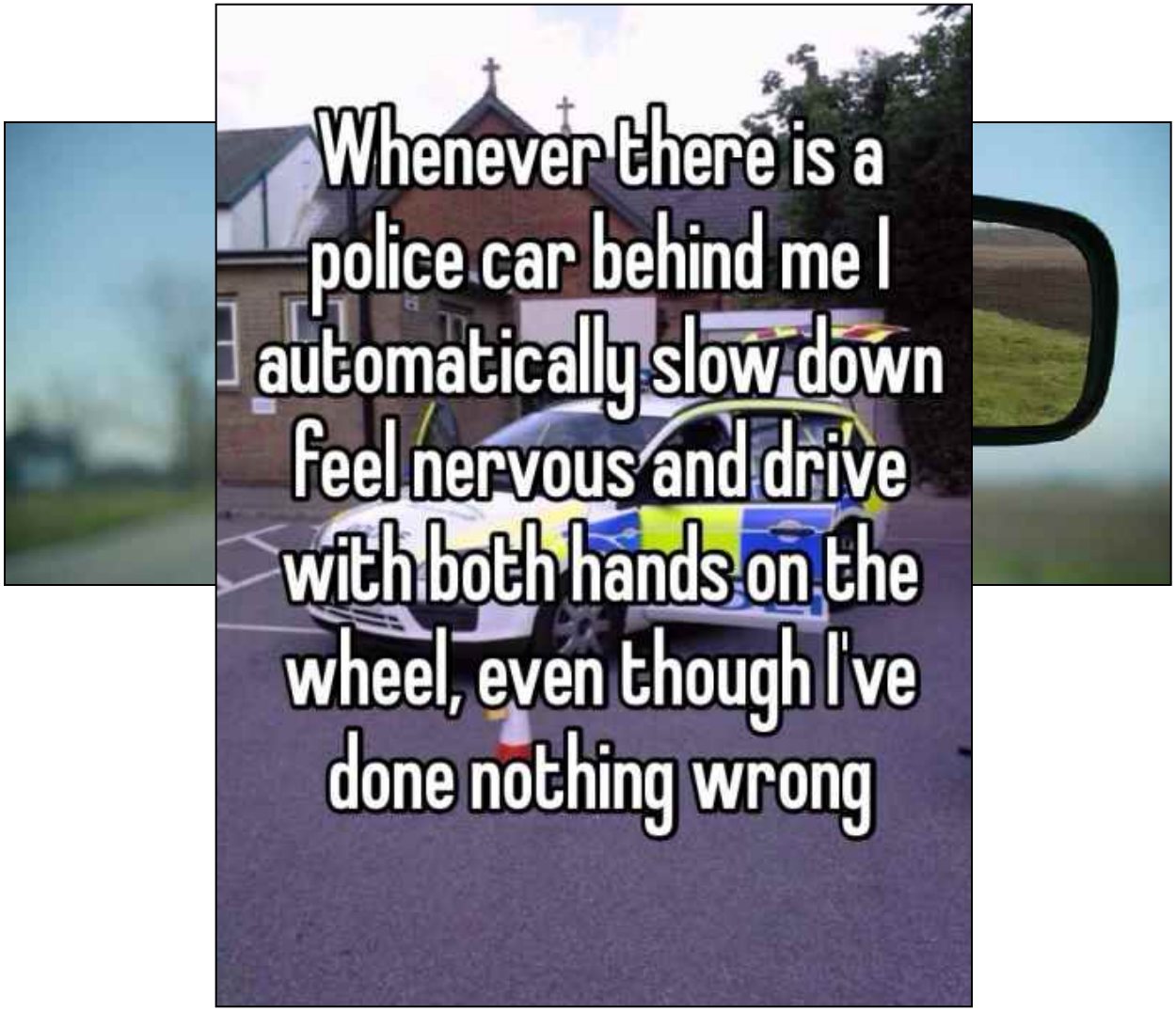
- Humanising characteristics placed upon car profile
- Precautionary stereotyping
- Expectation of certain behaviour from road user groups

"*Is that car smiling at me*?"

University of Toronto

University of Vienna

What we expect from other road users



Pareidolia

Reflecting on sight

Reflecting on sight

- Only species to use reflection intelligently and exogenously
- Back to front
- Convex mirrors – compound mirrors, variable radii
- Image distortion, greater with increasing eccentricity from plano centre. Binocular capability neutralised
- Speed and distance judgement impeded. Looming effect diluted. (USA & EU regs differ)
- HGV Class VI – back to front, convex, inverted
- Daytime – texture and colour assist
- Night-time – Reliance on motion and light stimuli - weakened

Reflecting on sight

External rear-view mirror illustrating the distance disparity between the image of the white car in the main, planar lens, and the convex top right lens.

Now for a mirror check before moving off

Now for that mirror check

So how do drivers deal with this?

- Mirror gaze dwell ≈ 0.5 to 1.5 seconds
- Longer for drivers of heavy goods vehicle and PCVs. Add time for head-turn to address remote mirrors
- Cognitive processing of data
- x *n+* (number of relevant mirrors + cognitive lag)
- Convex mirrors require extra care (USA & EU regs differ)

Remember:-

➢ at 30 mph a vehicle travels 13 metres per second

Is this what you saw? In enough detail?

Plunging ‘vision’ into darkness

- Low lighting level sight adjustment – 5 to 15 minutes
- Transitory retinal blindness – retinal ‘bleaching’
- Change in reliance from Cones to Rods (photopic to scotopic) or combination, dependent on lighting levels
- Contrast and conspicuity – often interchanged and misinterpreted. Perils for the “*there to be seen*” cases

Plunging ‘vision’ into darkness

Contrast:

- Metric – may be metered and quantified
- Observer (mainly) non-dependent
- Positive/negative contrast
- Gradient > 10% lighter/darker than surround (Weber Fechner Law)
- Visual texture – effect on degree of contrast
- Low light levels – stimulus draw

Plunging ‘vision’ into darkness

Contrast – positive and negative

Positive contrast

Negative contrast

Plunging ‘vision’ into darkness

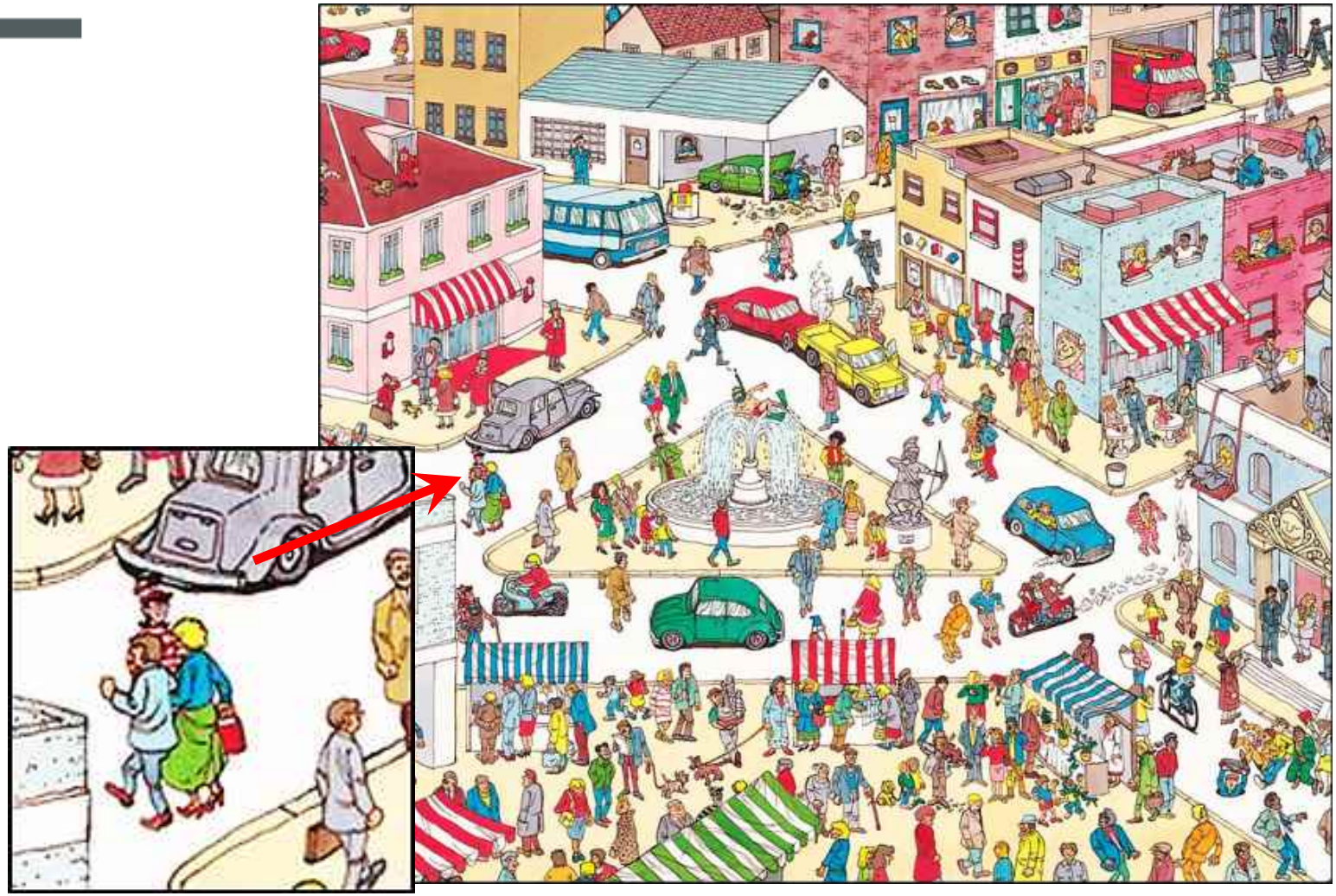
Contrast – stimulus draw

Plunging ‘vision’ into darkness

Conspicuity:

- Subject – observer specific
- Dependent on degree of cognitive salience – in-context
- Linked to ‘expectancy’
- Golf at Exeter Crown Court and The Old Bailey – why not?

Conspicuity



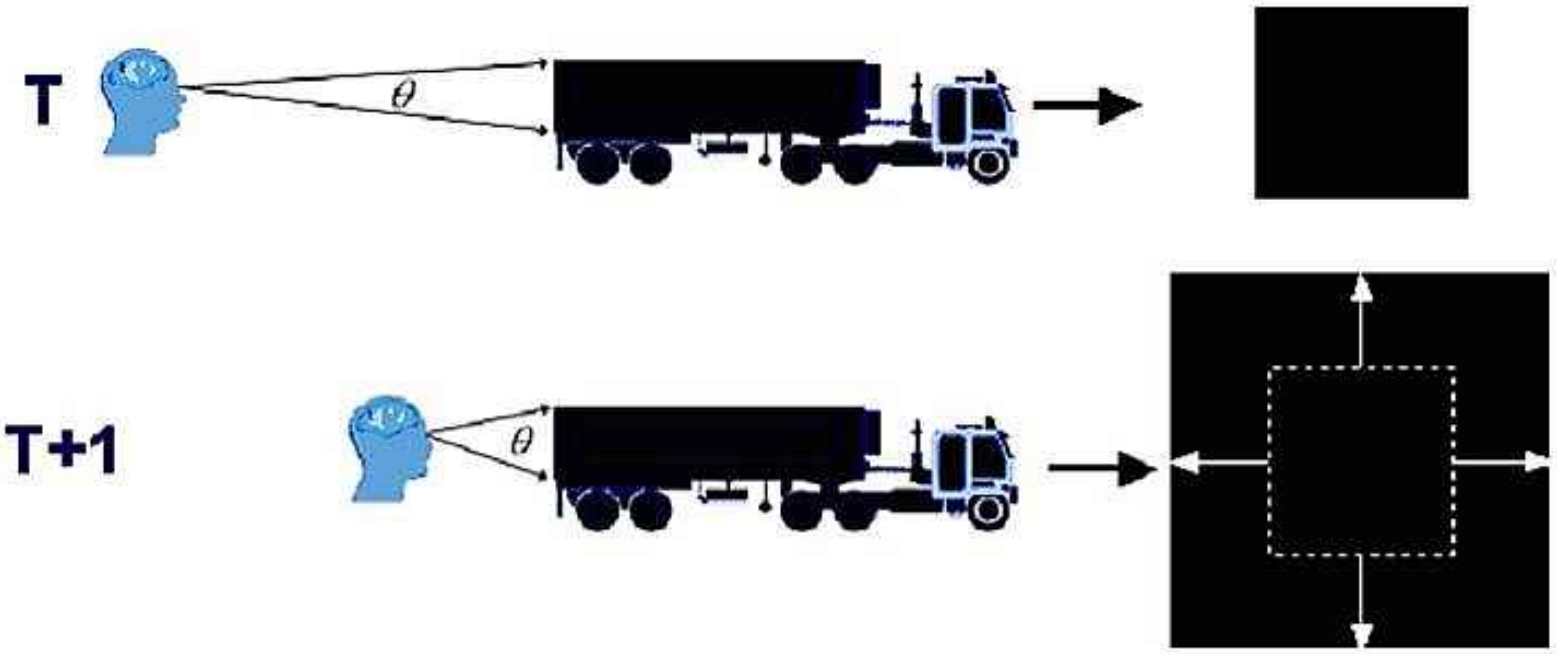
"*He came out of nowhere*" - Looming effect

- Combined sight and cognitive factor

Target object detected, at any given distance at a particular time 't', generates a given area occupied on the retina

- Closing or increasing distance over time, to time 't + 1' changes the area occupied on the retina
- Retinal image size can be either toward, or away
  – cognitive process is more sensitive with a closing distance
- The rate of change of expansion of the image gives the clue to the 'relative' speed of the object
- Research has identified sensitivity threshold from which the rate of change is likely to be effective – Looming threshold

Looming effect



Looming effect

Variables required;

- Approach speed – known or modelled
- Width of the object (more sensitive horizontally than vertically)
- Rate of change of subtended angle –
  - Muttart, 2006 (0.003 rad/s)
  - Hoffman, 1996 (0.006 rad/s)

Distance = √ speed x veh width / rate change

Gives a range (metres) from which the effect of approach speed is expected to be acknowledged

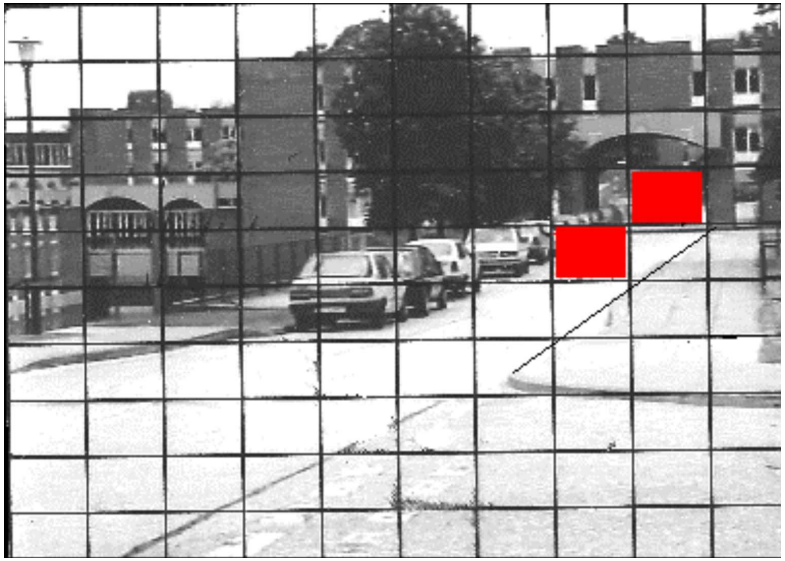
"*He came out of nowhere*" – Where we look

- Experienced/inexperienced driver/rider
- Detection – Looming effect, contrast/conspicuity
- Expectancy/in-context
- Change blindness
- Primary cognitive salience – what's important to us at the time
- 'Single channel' animal – sorry folks, we cannot multi-task – System I and System II - Kahneman

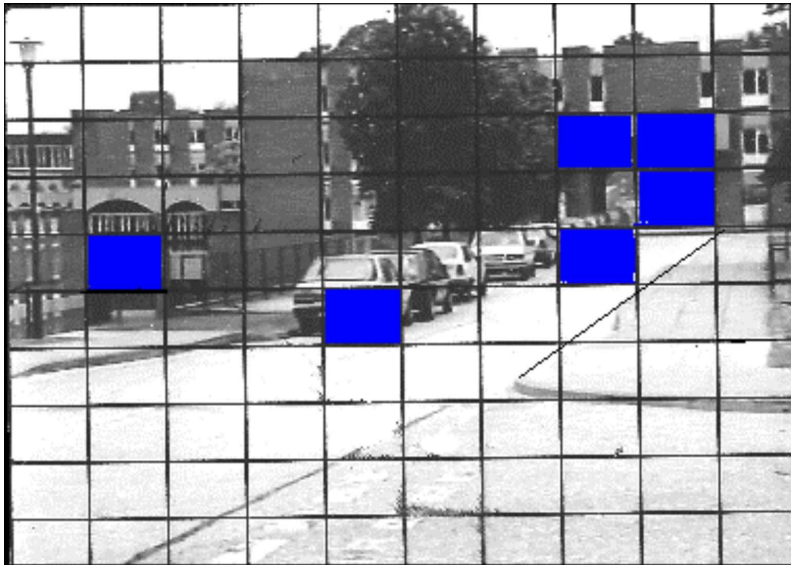
"*He came out of nowhere*" – Where we look

Langham *et al* (1997) 'What do drivers do at junctions?'
Saccadic behaviour in junction actions

'No vehicle present'



Experienced driver



Inexperienced driver

Psychological incompatibility

Langham *et al* (1997) 'What do drivers do at junctions?'
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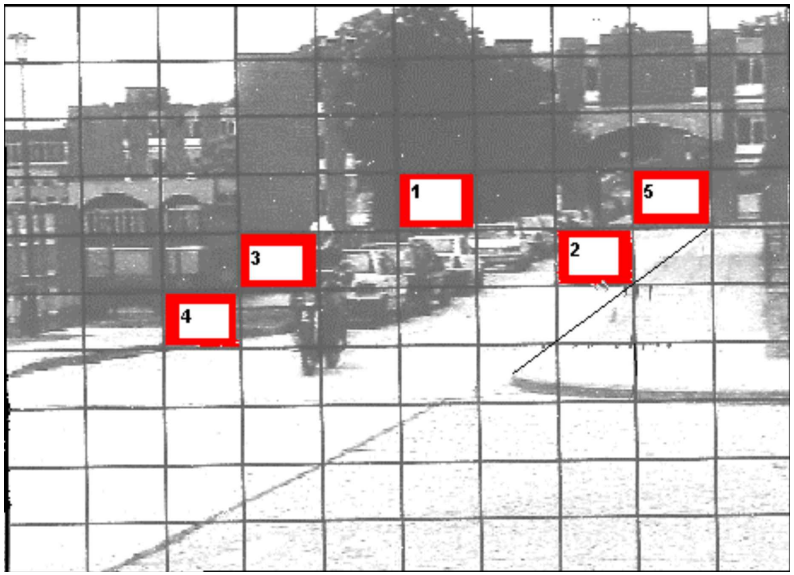

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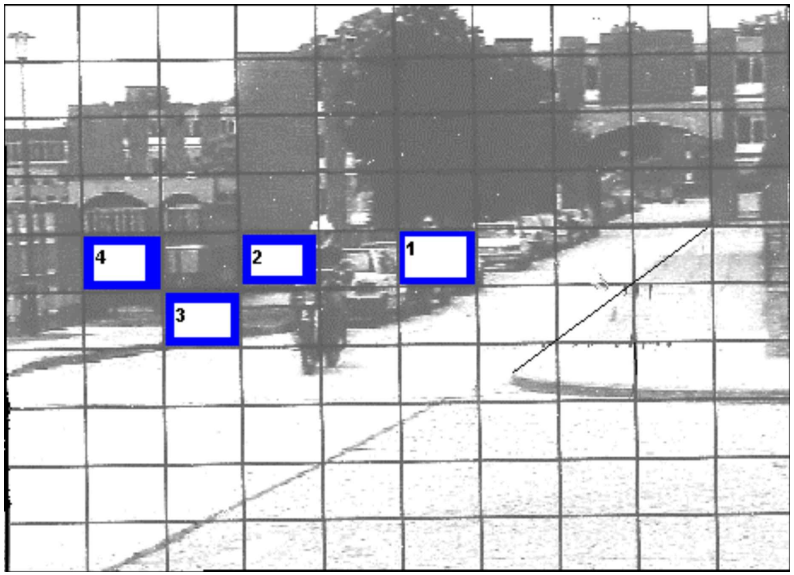


Inexperienced driver

Cognitive salience – does it matter?

‘Looked but failed to see’

Change blindness – O’Regan; Simons & Levin/Chabris

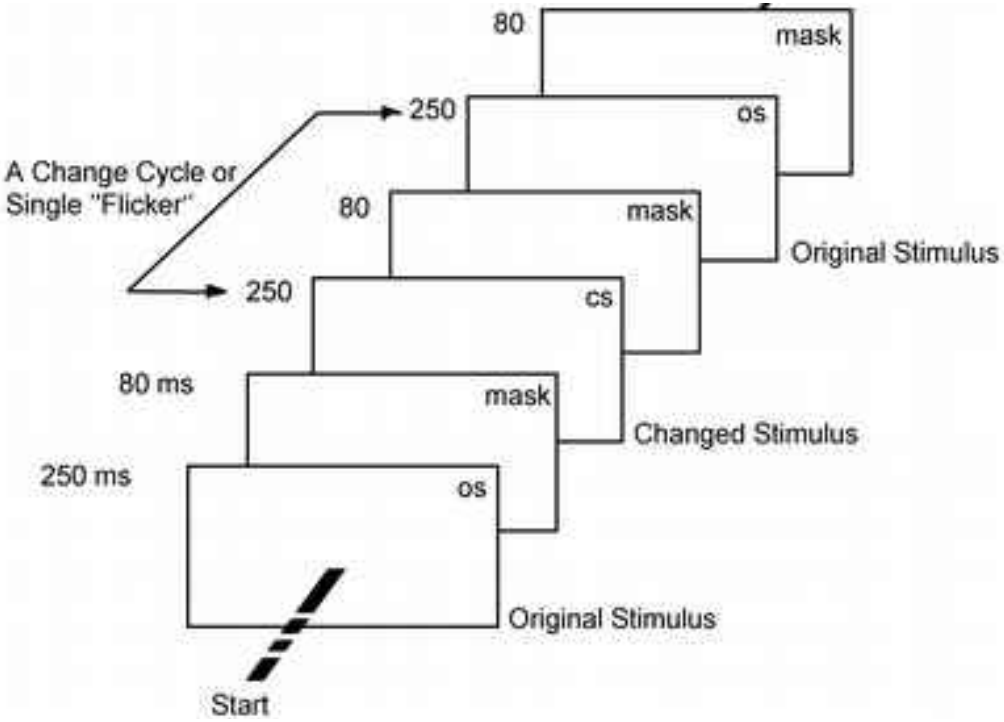
- Up to 1/5 of scene can change between observations, whether eye movements or ‘flicker’ interruptions
- ‘Lazy’ brain ‘short-cuts’, relying on previous observation with only confirmation from second gaze
- What we look for and see is our memory and what is of primary cognitive salience – at our peril

The -Door- Study.mp4

Back to basics – Is seeing really believing?

Change Blindness

Inability to spot changes in sight-line, when interrupted by saccades



Change Blindness

Mark Hill MSc MFSSoc

Perception Response Time (PRT)

PRT – "*Interval that starts when an object or condition first becomes possible for a reasonably alert driver to detect, and ends when the driver has initiated a discernible response*." (Krauss, Todd, & Olson)

Typical PRT is suggested to be between 0.75 & 2 seconds, during which the vehicle is still moving at the same speed.

Influenced by;

- Cognitive workload
- Strength of stimulus
- Eccentricity of stimulus
- Expectancy
- Context
- Fatigue
- Response complexity
- Toxicology

Distraction

May take the form of ‘legitimised distraction’

- Mirror check
- Instrument check
- Target gaze – e.g. toward turning or entrance

or

‘Non-legitimised distraction’

- Mobile phone usage
- In-vehicle entertainment
- Passenger conversation
- Sat-nav
- Eating/drinking

...although all a matter for the Court

Distraction

Patience is a virtue

Thank you for your interest
and attentiveness. I hope that this
presentation has given food for thought.

I welcome any questions
that you may have.

Should you wish for more information on any of the matters that this presentation has touched upon,
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