

# Isabelle Mareschal

Spatiotemporal characteristics of human gaze  
processing

# Relevance of gaze?

## Fundamental role in social interactions

- \_ Determine another's focus of attention (Frischen et al., 2003)
- Establish joint attention (Dunham & Moore, 1995)
- Facilitate verbal communication, such as signalling turn-taking in conversation (Argyle & Cook, 1976)
- Infer the mental states of others (Baron-Cohen et al., 1995)

## Affected in a range of clinical conditions

- Schizophrenia (Langdon et al, 2006)
- Autism (Pellicano et al, 2013)
- Social Anxiety (Gamer et al, 2011)

## Innate

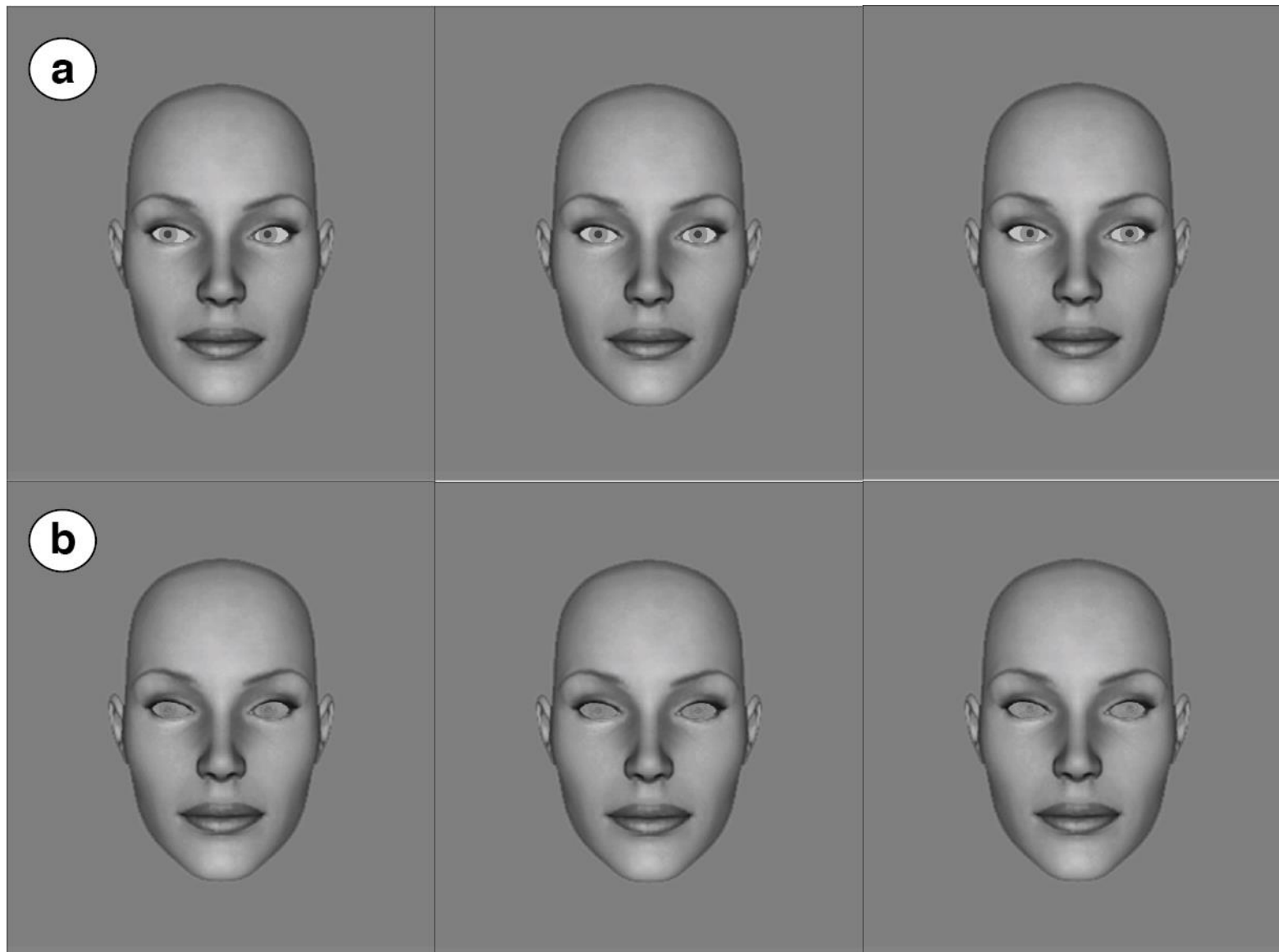
- Newborn babies spend longer looking at faces with direct (Farroni et al. (2002)
- Children of blind parents do not display abnormal gaze behaviour (Senju 2013)

# Spatial properties of gaze revealed using psychophysical techniques

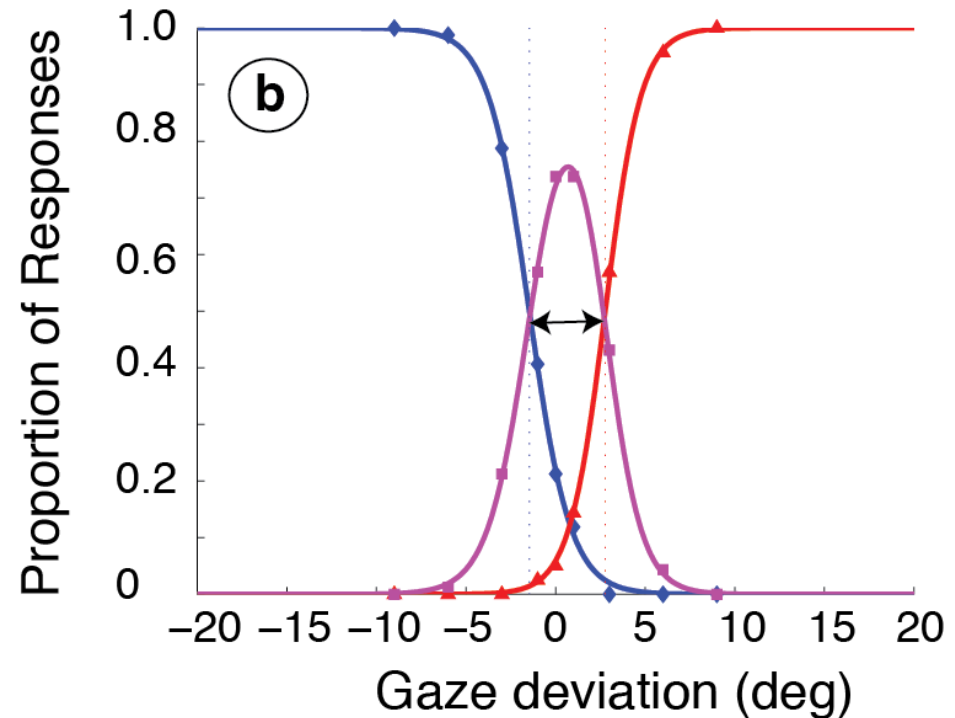
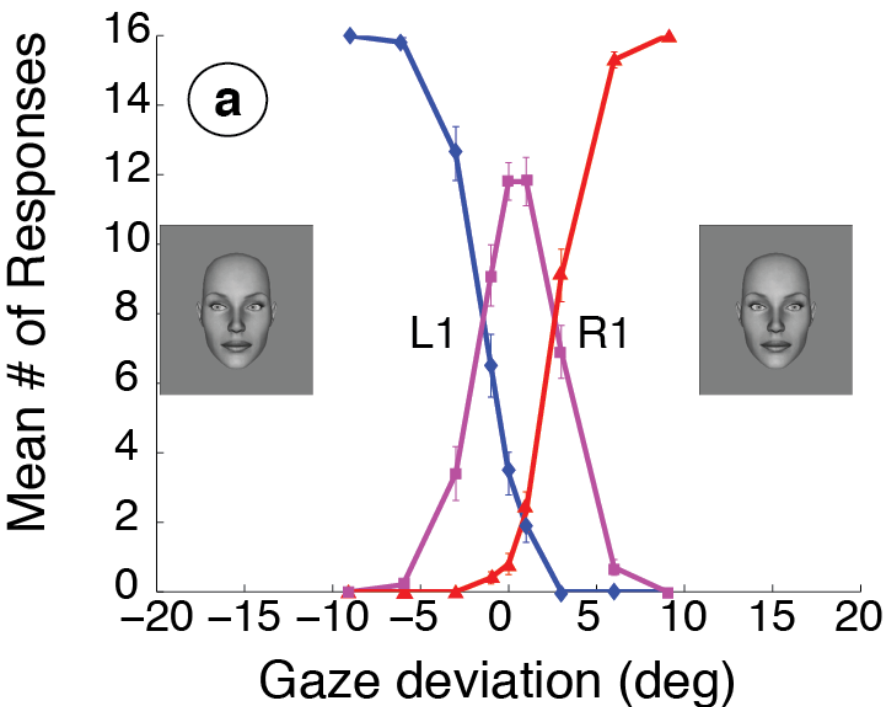


<i><b>Task</b></i>	<i><b>Measurement</b></i>
(1) Categorization	Cone of direct gaze
(2) Adaptation	Gaze channels
(3) Discrimination	Prior for direct gaze

# (1) Categorization

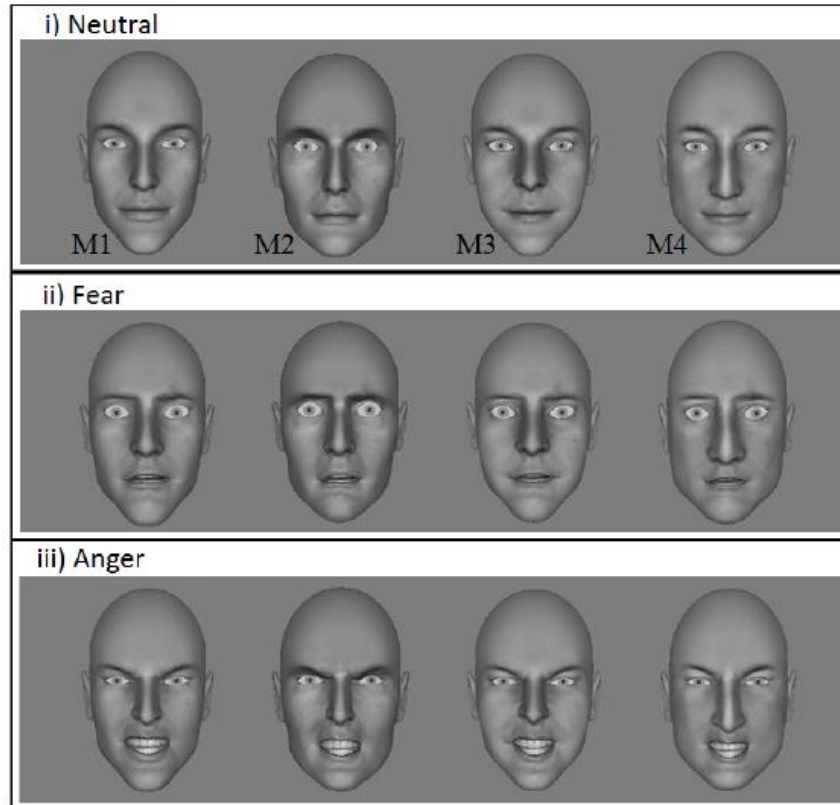


Obtain measure of “cone of direct gaze”  
Corresponds to range of gaze deviations judged as “direct”

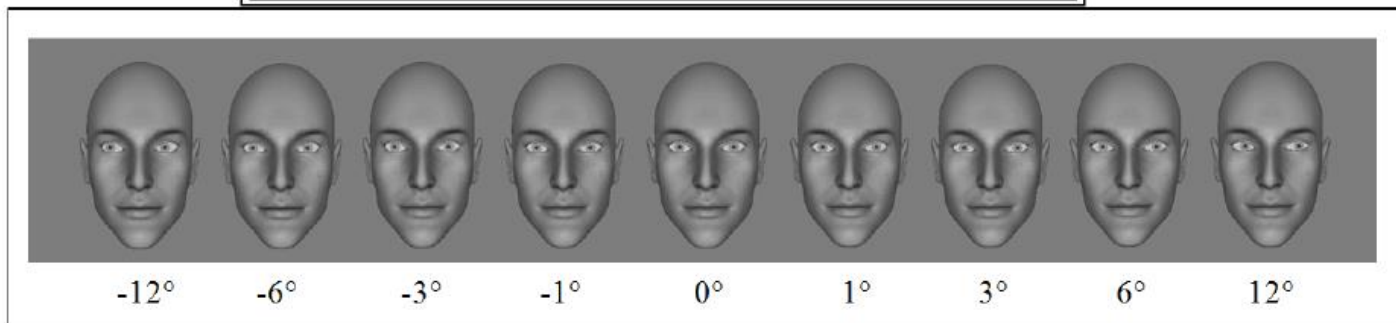


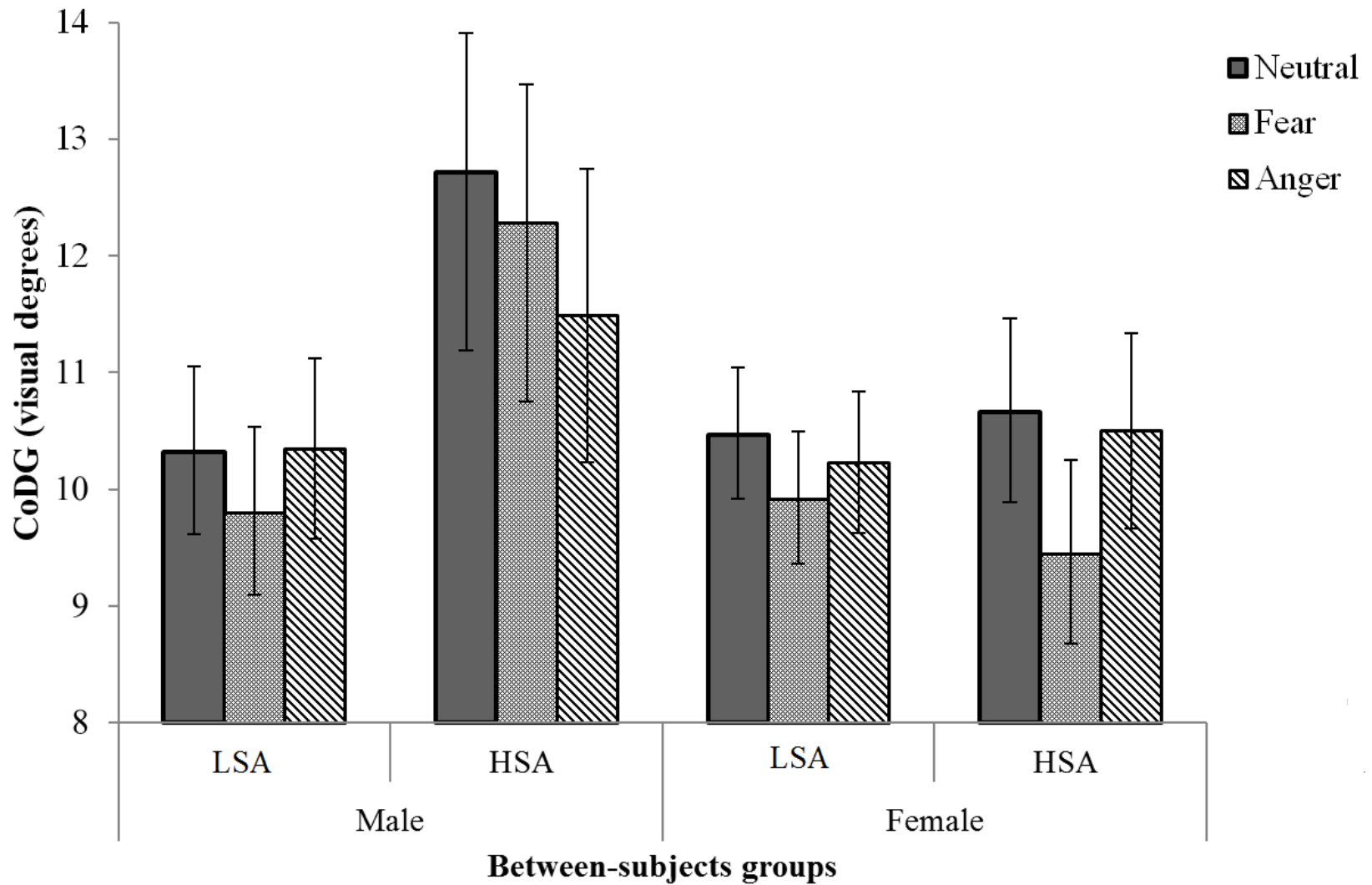
# Cone width as a function of personality type

a



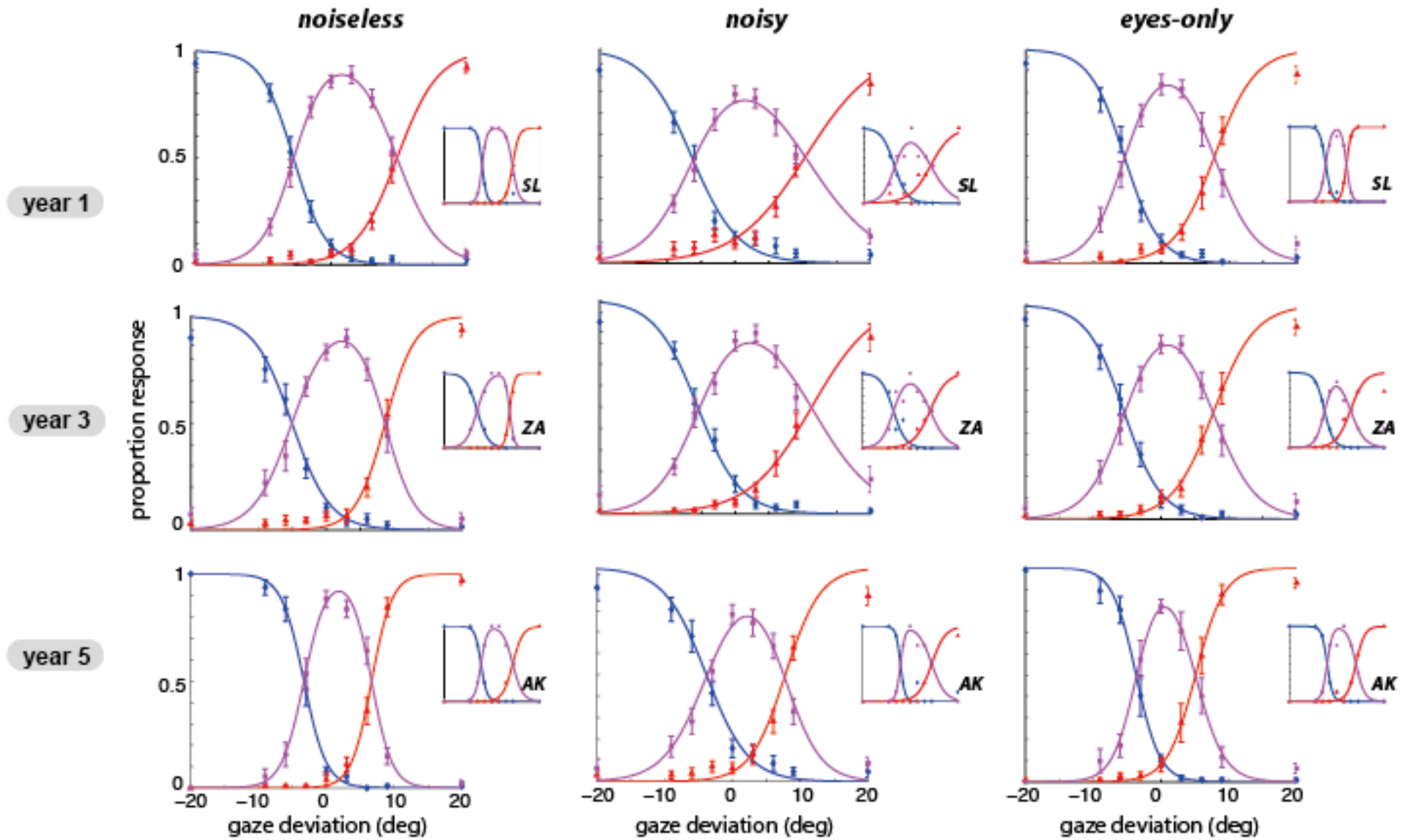
b





Cone width marker for social anxiety (Jun, Mareschal, Clifford & Dadds, 2013);

# Cone width as a function of age





## 2 Adaptation

**Protocol:** prolonged exposure to a particular type of stimulation

**Process:** changes induced in neural mechanisms

**Perception:** changes induced in perceptual experience

# Demo

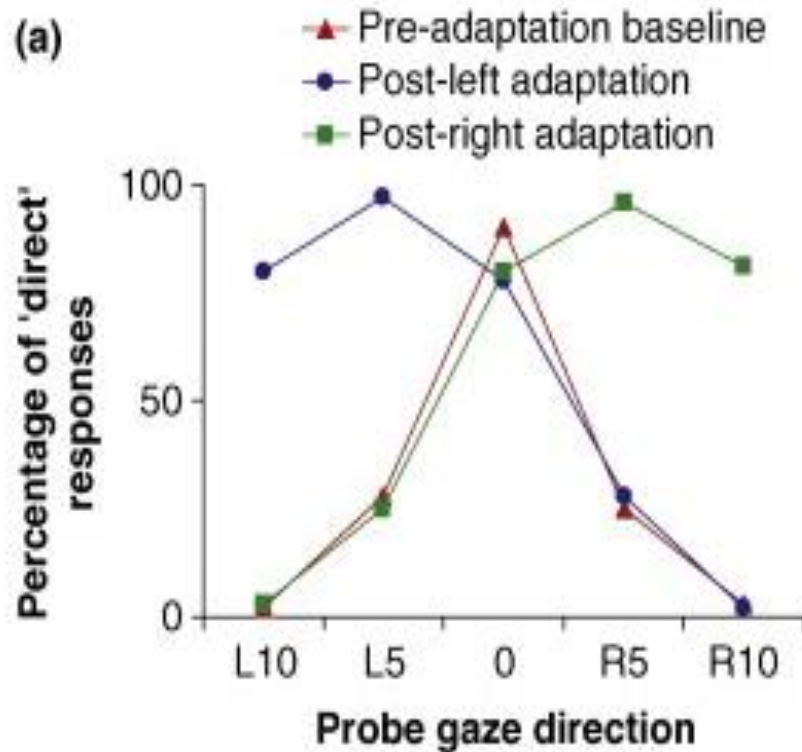


More averted?

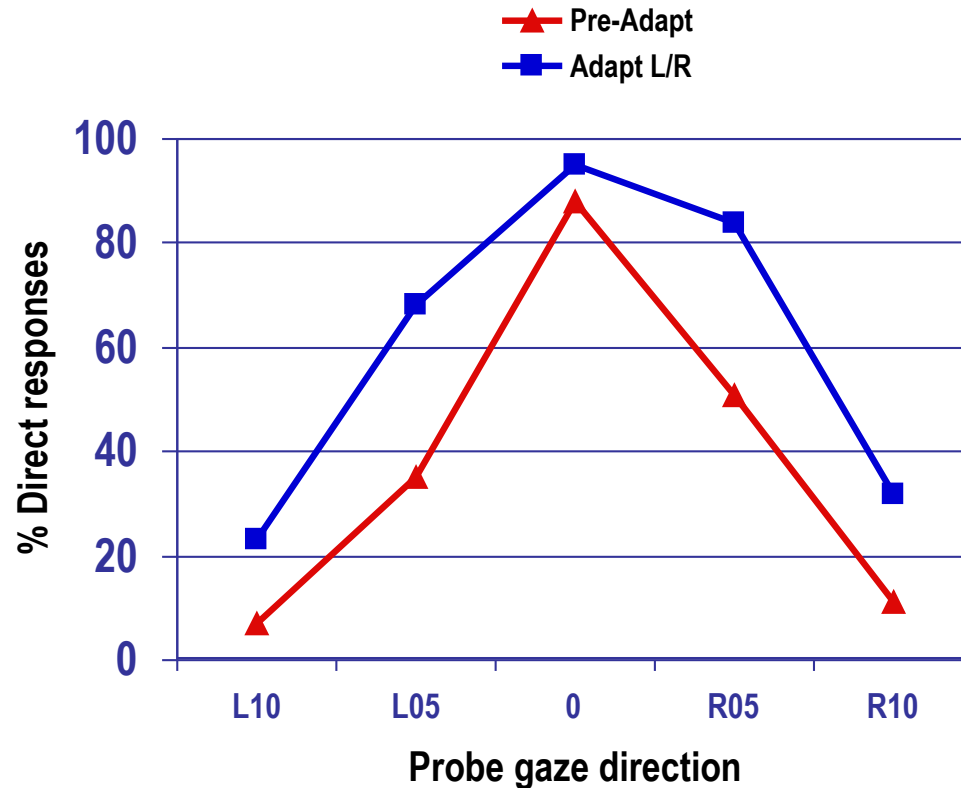




## (a) Non-interleaved Averted Gaze



## (b) Interleaved left/right averted



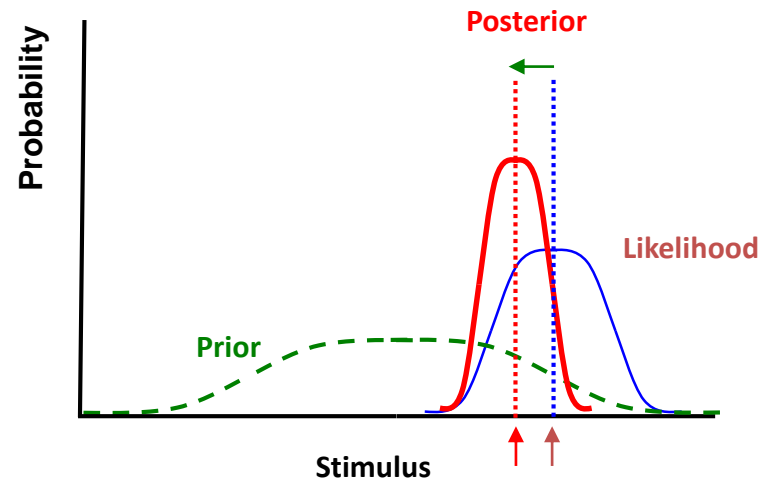
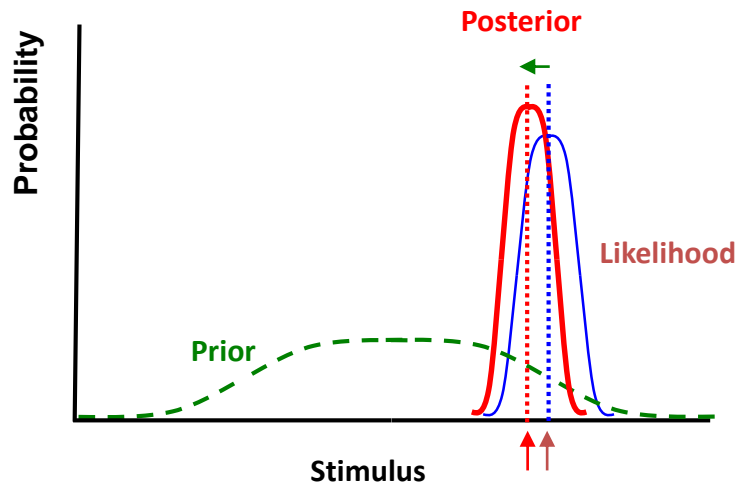
Adaptation to interleaved presentations led to an increase in the cone of direct gaze, as predicted by a multi-channel system

### (3) Prior for direct gaze



# Prior Expectation within a Bayesian Decoding Framework

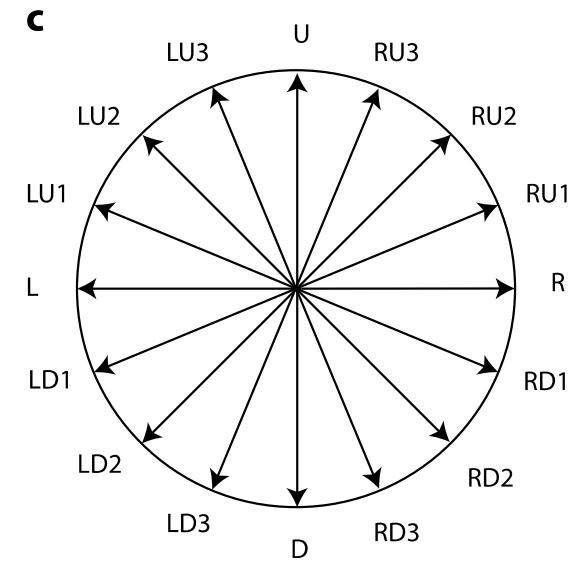
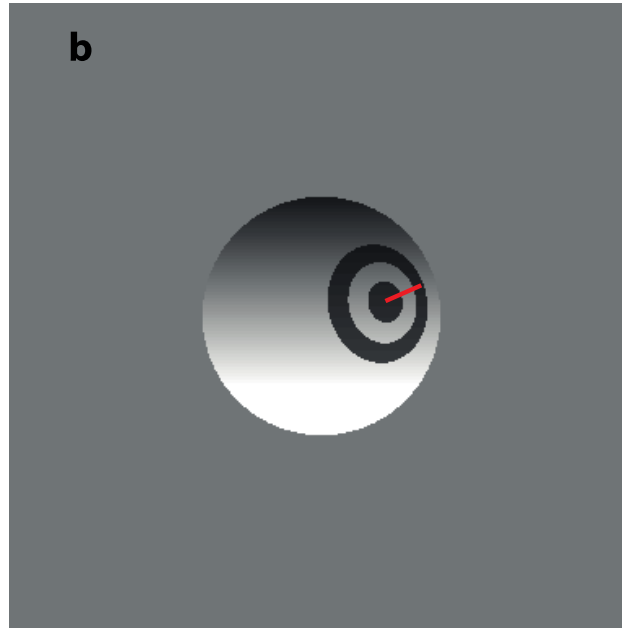
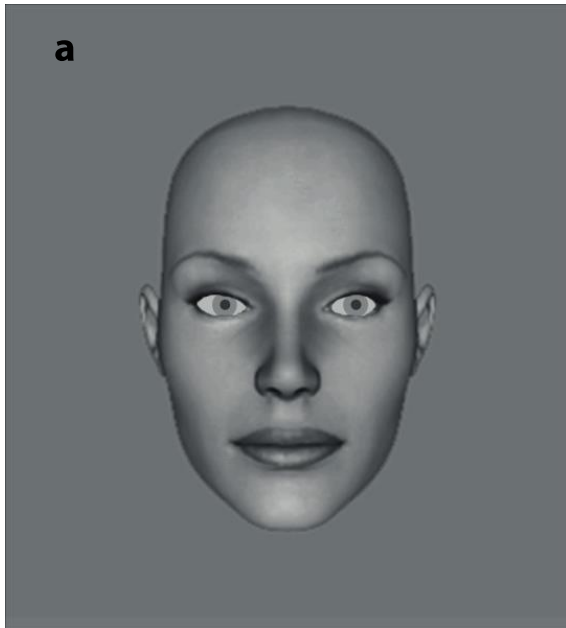
Increasing the uncertainty in a stimulus increases the influence of the prior, effectively “pulling” the perceived direction of gaze toward the peak of the prior distribution.

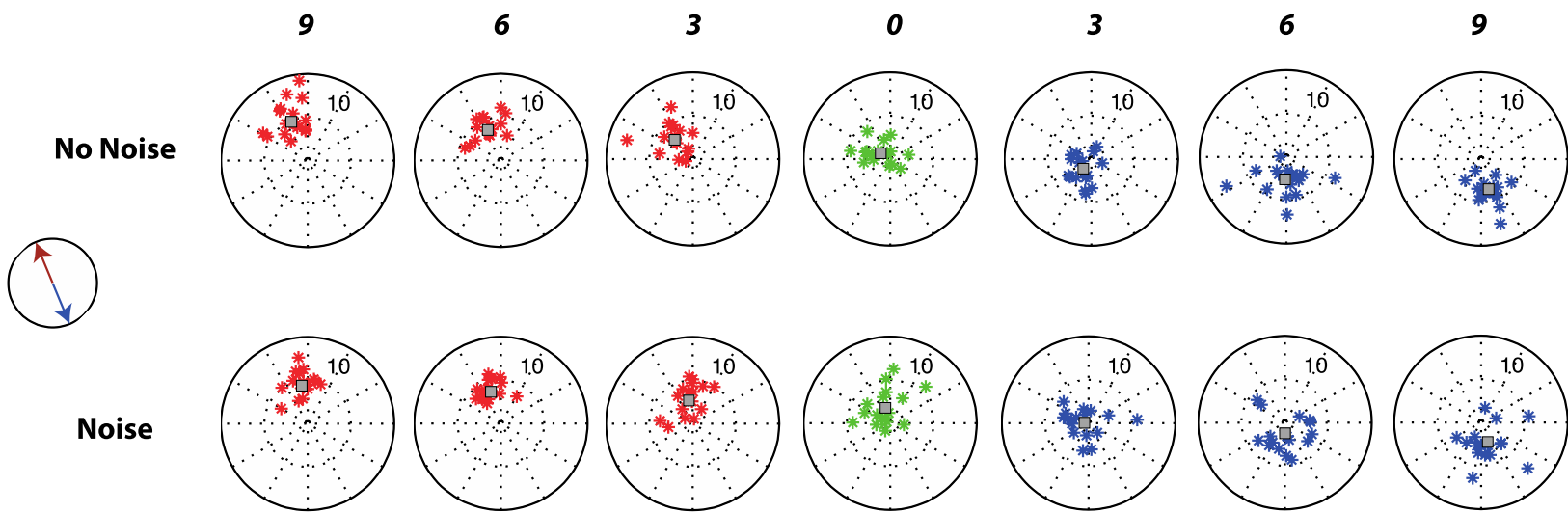


(Mareschal, Calder & Clifford, 2013, Current Biology).

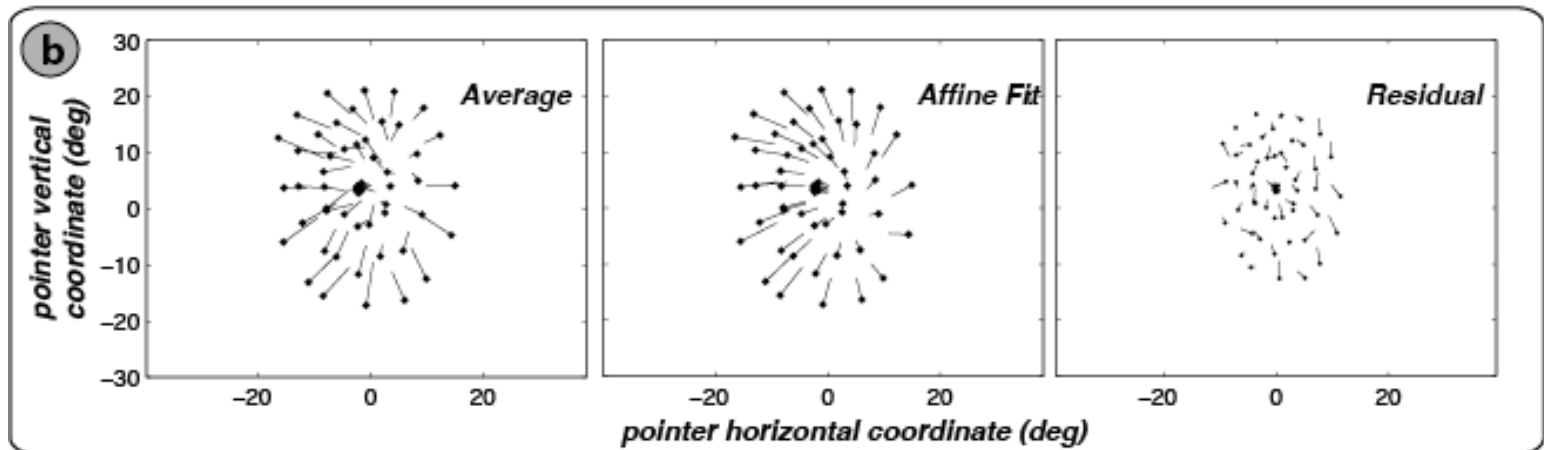
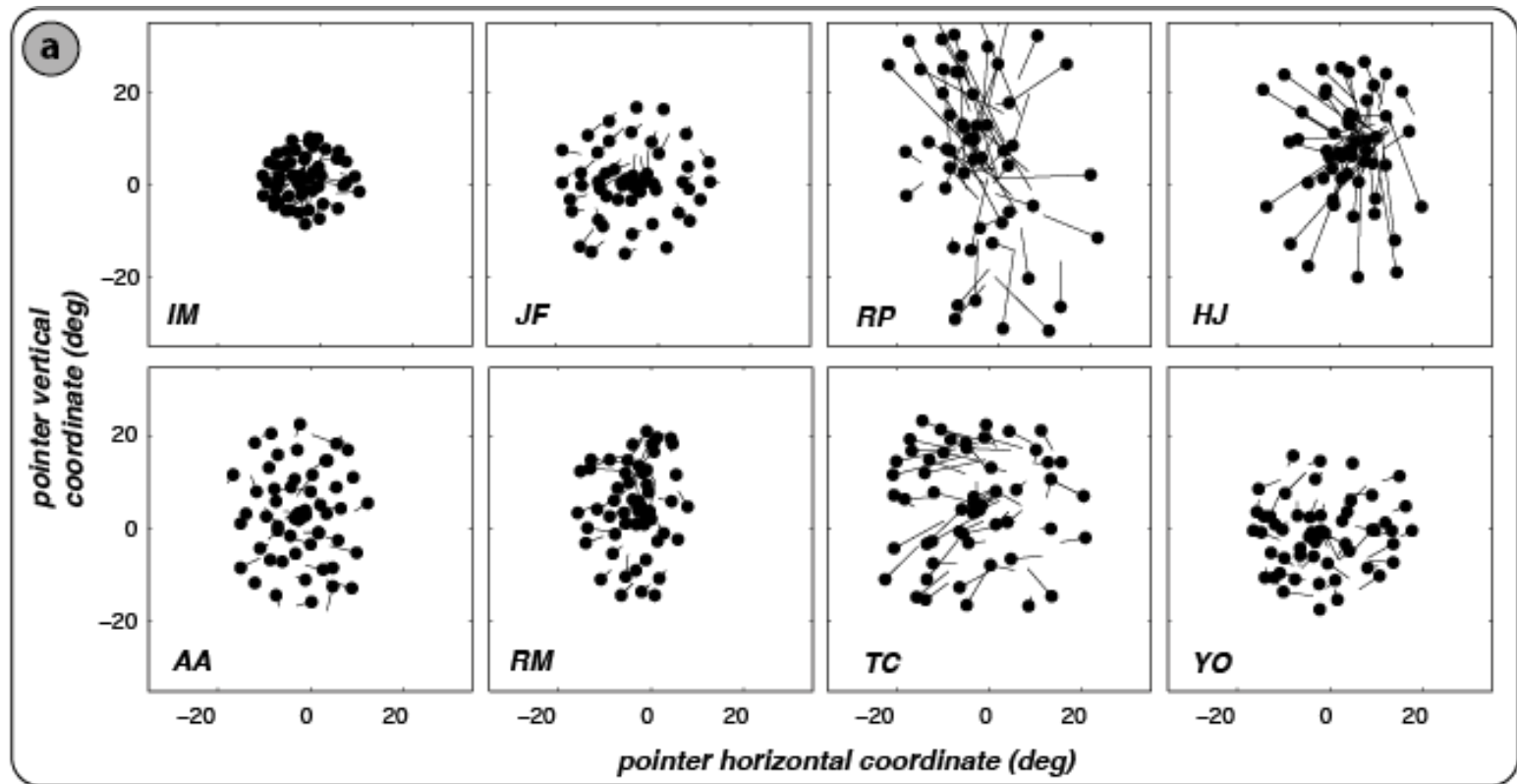


# Prior for cardinal directions of gaze?





# Direction of gaze in forward facing heads



# Temporal properties of gaze

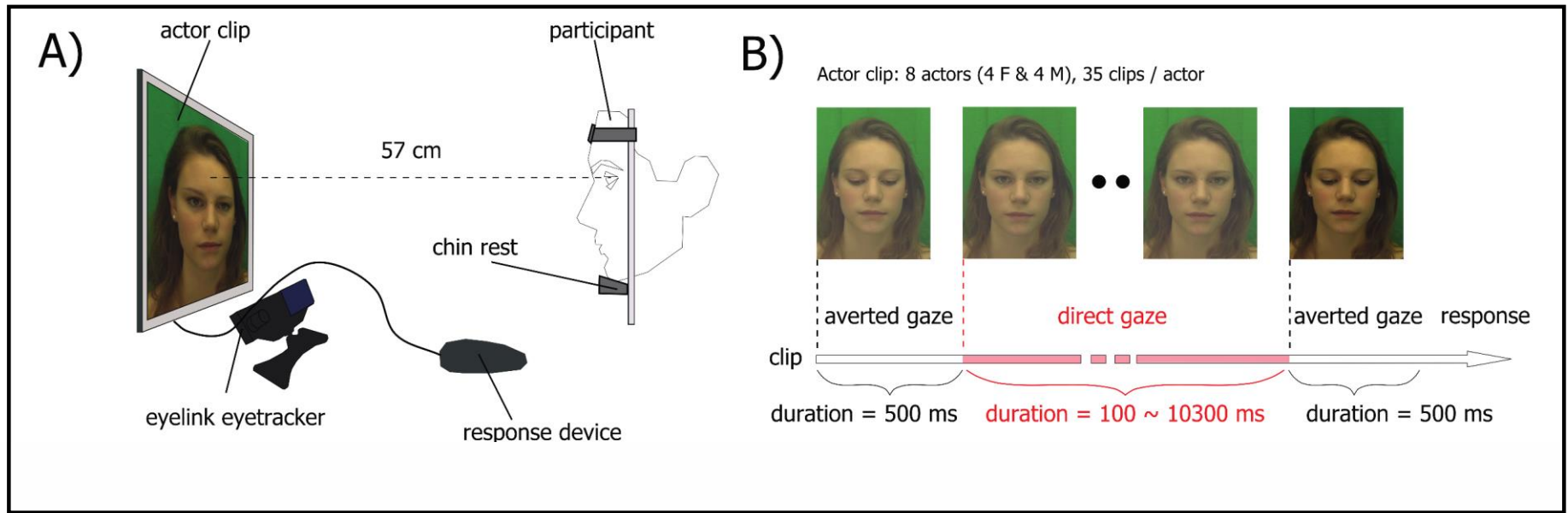
Social interactions are highly dynamic: *How long* and *when* a person looks is as important as *where* they are looking



# Eye Tracking to evaluate temporal characteristics of gaze

Science Museum London



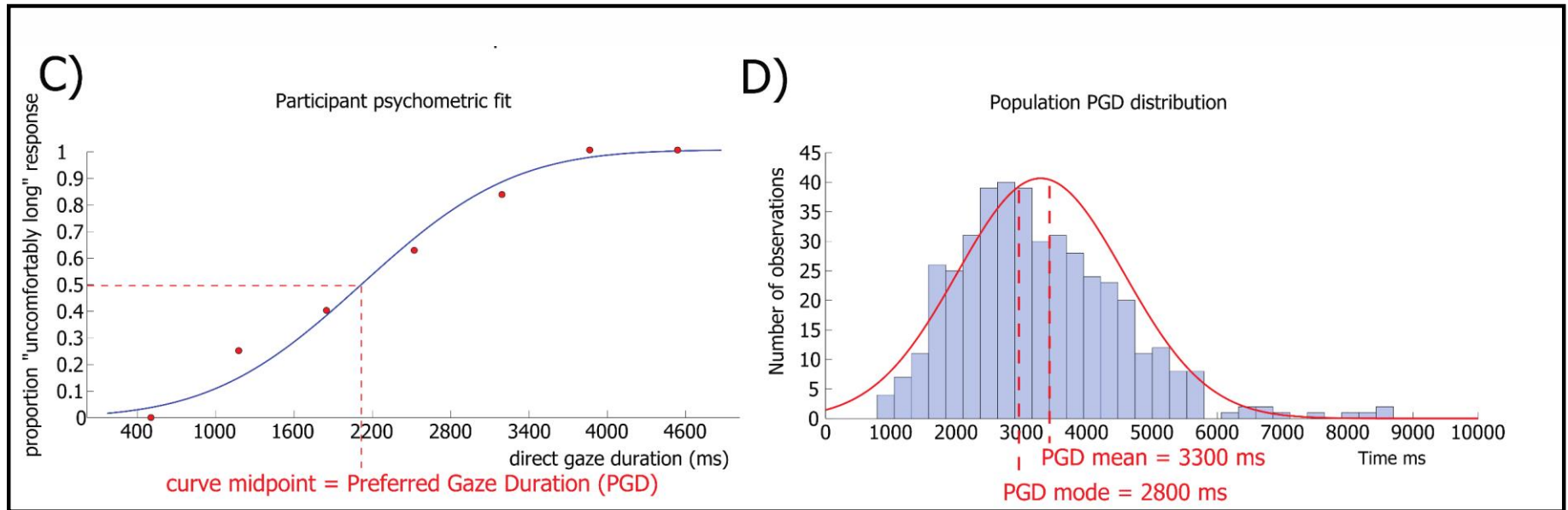


<http://www.sciencemag.org/news/2016/07/video-how-long-can-you-make-eye-contact-things-start-get-uncomfortable>

# Methods

- 8 faces, 35 clips of different durations, 40 trials/participant
- 498 participants:
  - 463 with eye data
  - 410 with good psychometric curve } 380 with both
- For each participant:
  - 4 face ratings (dominance, threat, trust, attractiveness)
  - 5 personality traits (openness, conscientiousness, extraversion, agreeableness, neuroticism)

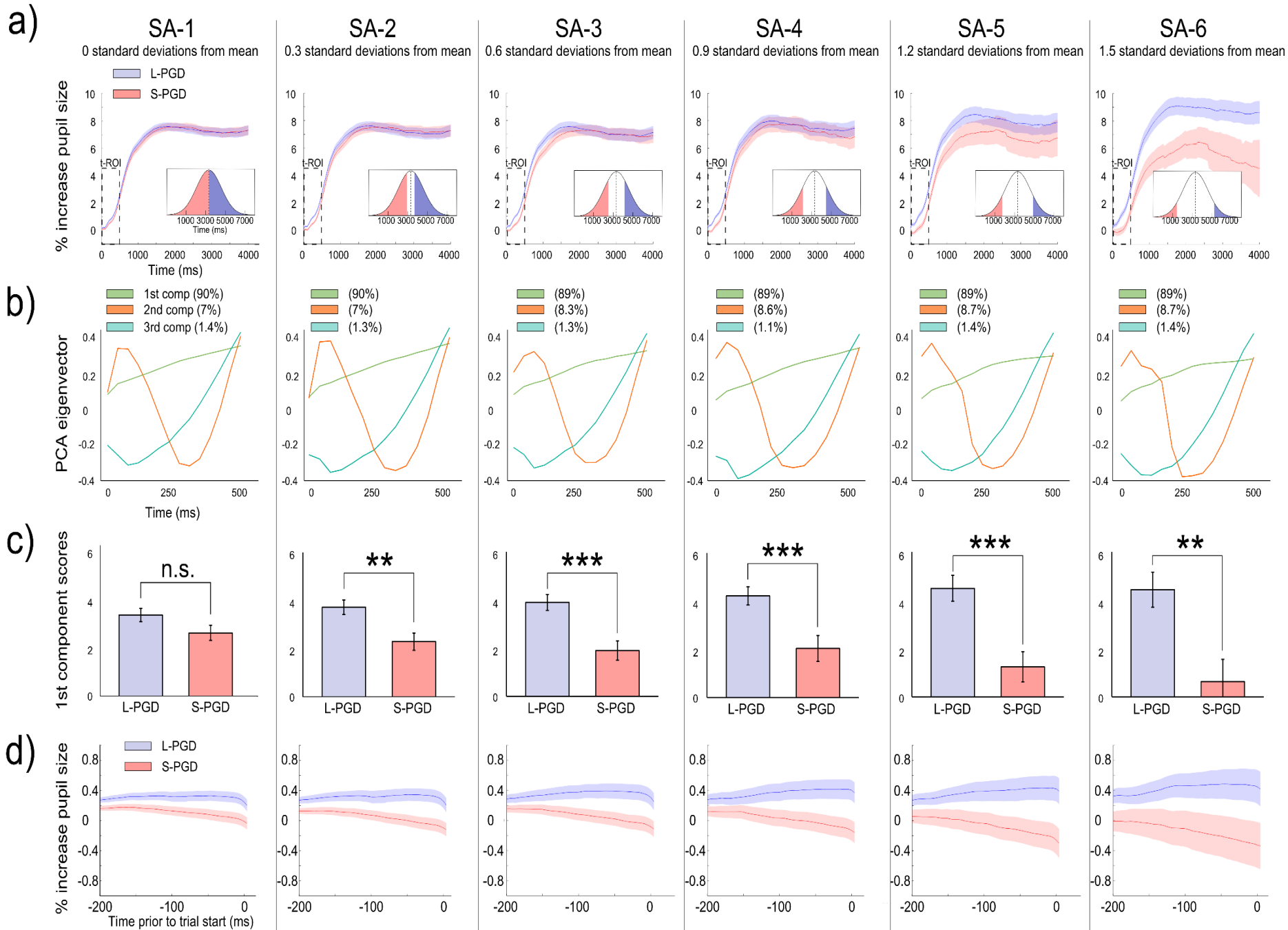
# Behavioural measure of preferred gaze duration





# Results part 1:

- 1) The average PGD is roughly 3.3 seconds.
- 2) The only actor variable to be correlated with PGD was “threat”: higher threat scores were correlated with lower PGD ( $p < 0.005$ )
- 3) Surprisingly, there was no correlation between personality scores and PGD.
- 4) Possible caveat is that none of the actors ratings were very high/low on the 4 traits



## Results part 2:

- People who prefer longer amounts of eye contact have a faster rate of pupil increase.
- Increases in pupil size are linked to arousal.

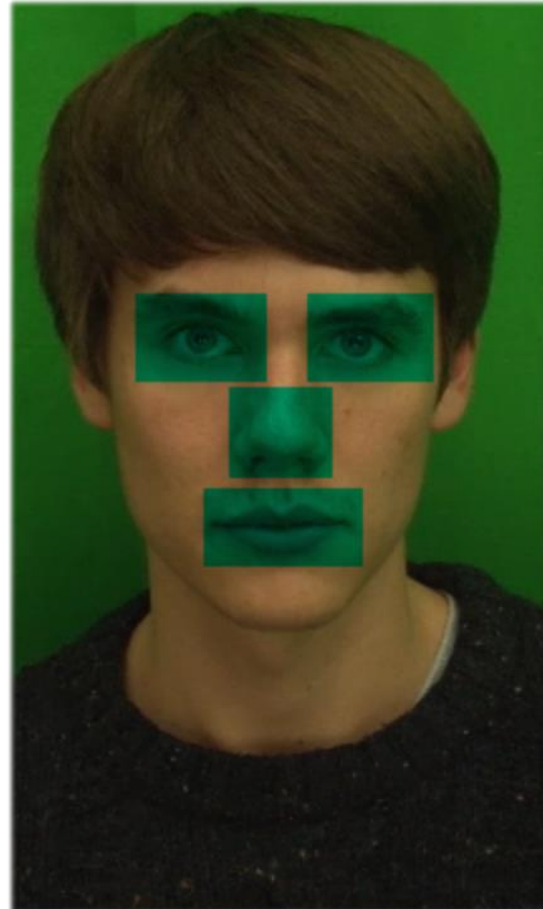
*Binetti, Harrison, Coutrot, Johnston & Mareschal (2016). Proc Roy Soc, Open Science*

# Scan path analysis

Quantifying gaze behaviour:

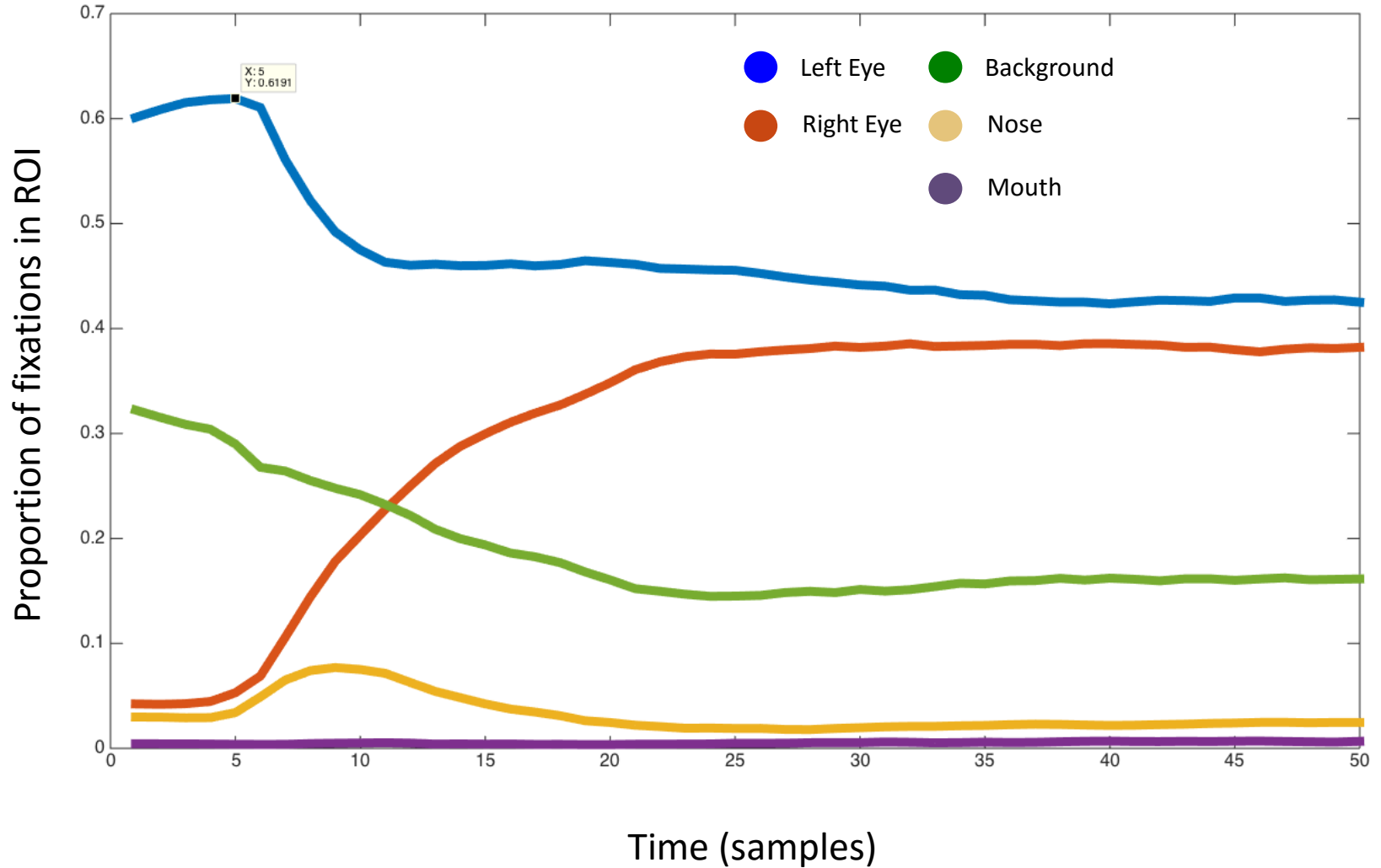
- **Dispersion:** variance between the eye positions of different participants  
or  
variance between the eye positions of the same participants
- **Fixation Duration**
- **Saccade Amplitude**
- **Proportion of fixations in different Regions of Interest (ROI)**

## Proportion of fixations in different Regions of Interest (ROI)



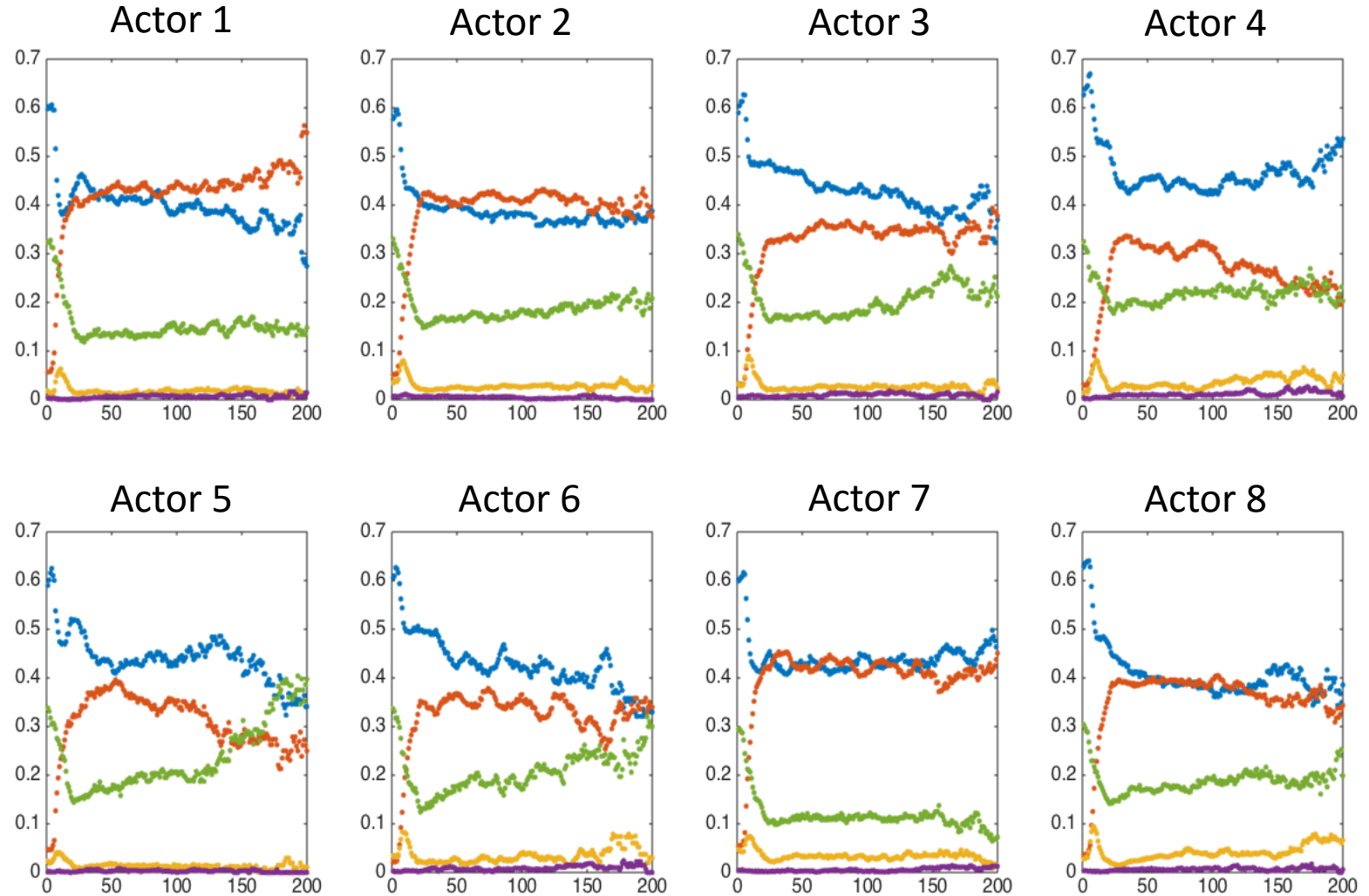
**5 ROIs:** left eye, right eye, nose, mouth and background,  
defined for each actor and each clip

# Proportion of fixations in different Regions of Interest (ROI)

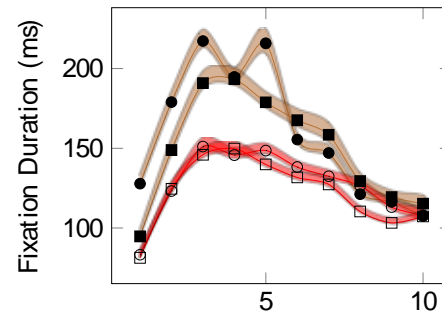


# Proportion of fixations in different ROI by actor

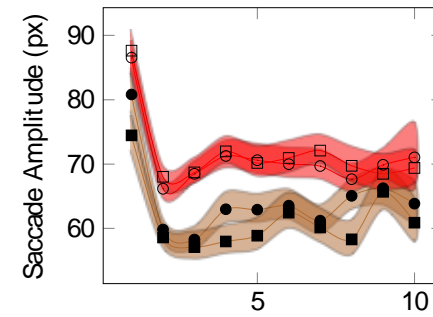
● Left Eye ● Right Eye ● Background ● Nose ● Mouth



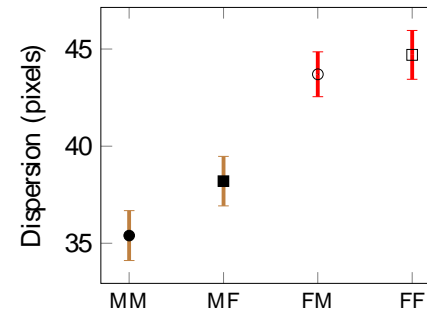
# Gender Differences in Eye Movements



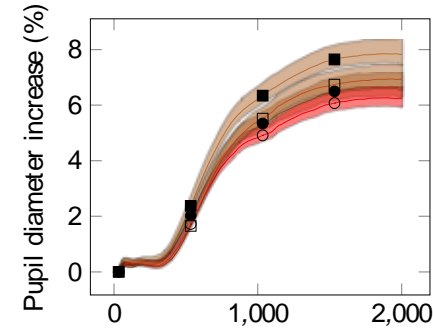
(a) Fixation Number



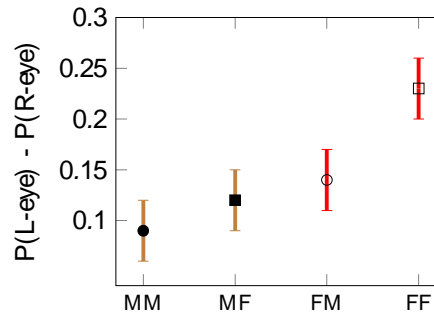
(b) Saccade Number



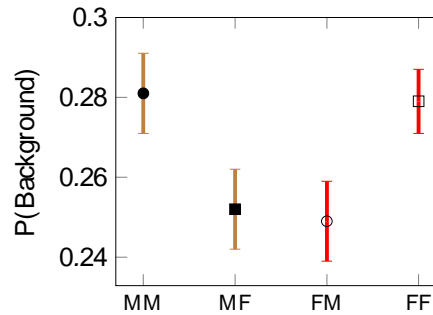
(c) Gender



(d) Time (ms)



(e) Gender



(f) Gender



*Coutrot, Binetti, Harrison, Mareschal & Johnston (2016). Under Review*



# Scan Path results

- Very strong left eye bias: unclear why this is the case
- Fundamental differences in scanning behaviour between men and women.
- Possible to build a classifier using the scan path data that distinguishes gender of participant with 72% accuracy

# Conclusions

- Eye tracking / pupillometry is a promising method to uncover fundamental characteristics (PGD and pupil size), bypassing verbal report.
- Gazing behaviour (for faces) is diagnostic of gender.

# Thank you

**Prof Colin Clifford** Psychology Department, *University of new South Wales*

**Dr Andrew Calder** MRC, *Cambridge*

**Prof Alan Johnston** Psychology Department, *University of Nottingham*

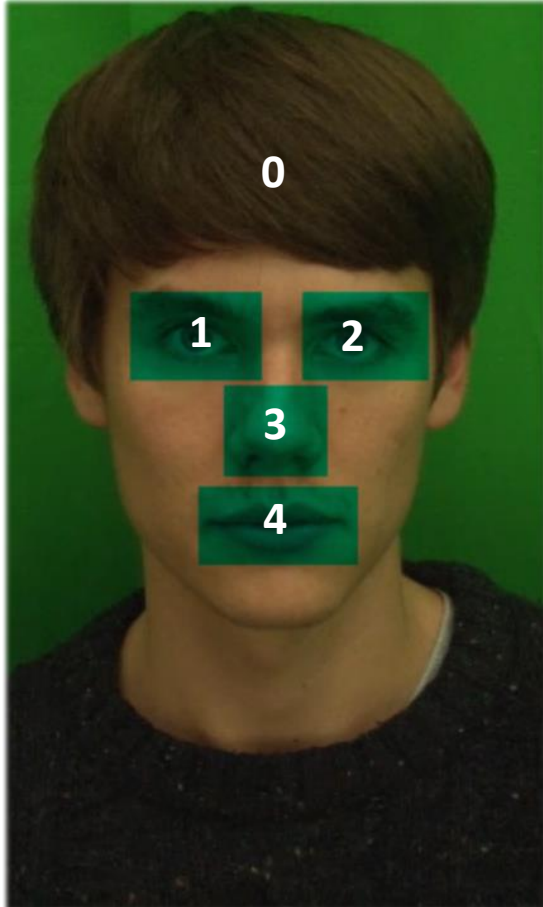
**Dr Antoine Coutrot** Centre for Maths, Physics and Engineering in the Life Sciences,  
*University College London*

**Dr Nicola Binetti** Psychology Department, *University College London*

**Ms Charlotte Harrison** Psychology Department, *University College London*



# Similarity between scanpath : same observer



sub i 111111000000000000222222222111111111111022

sub j 111111122222222222222222222222333333200002222222222222222222

**Levenshtein distance:** count the number of insertions, deletions or substitutions required to change one scanpath into the other

