

Data driven group comparisons of eye fixations to dynamic stimuli

Frouke Hermens

Outline

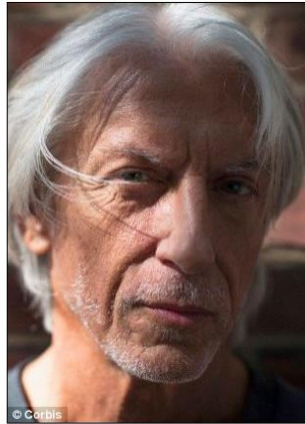
- ▶ Introduction
 - ▶ Saccade diagnostics
 - ▶ Eye tracking
 - ▶ Analysing eye movement data
 - ▶ Dynamic stimuli
- ▶ Method
- ▶ Results
- ▶ Future directions

Saccade diagnostics

Saccade diagnostics

New '100% accurate' test diagnoses schizophrenics simply by checking their gaze

- Tests revealed schizophrenics find it harder to maintain a steady gaze
- The eye tests are simple, cheap, and take only minutes to conduct, say researchers



Scientists have developed an almost 100 per cent accurate test to detect schizophrenics - by checking their gaze (posed by model)

<https://www.dailymail.co.uk/health/article-2225792/New-100-accurate-test-diagnose-schizophrenics.html>

<https://www.scotsman.com/news/eye-test-gives-flicker-hope-psychiatric-patients-1470640>

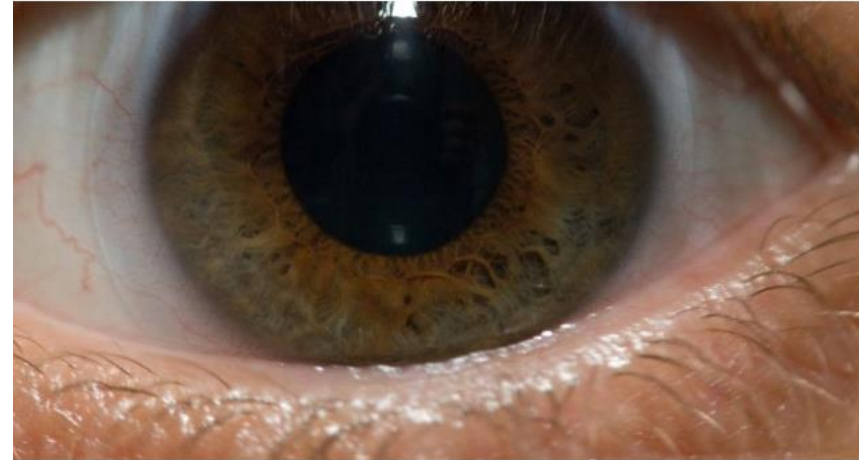
Eye test gives flicker of hope to psychiatric patients

A simple eye test which could speed up the diagnosis of serious psychiatric disorders – and alleviate suffering of millions of patients worldwide – is now delivering 'solid' results in a global trial.

By [The Newsroom](#)

Thursday, 4th August 2016, 5:58 pm

Updated Thursday, 25th August 2016, 4:20 pm



A simple test of eye movements developed at Aberdeen University could help diagnose psychiatric illness more quickly. PIC Stefan Schroeder/Wikicommons.

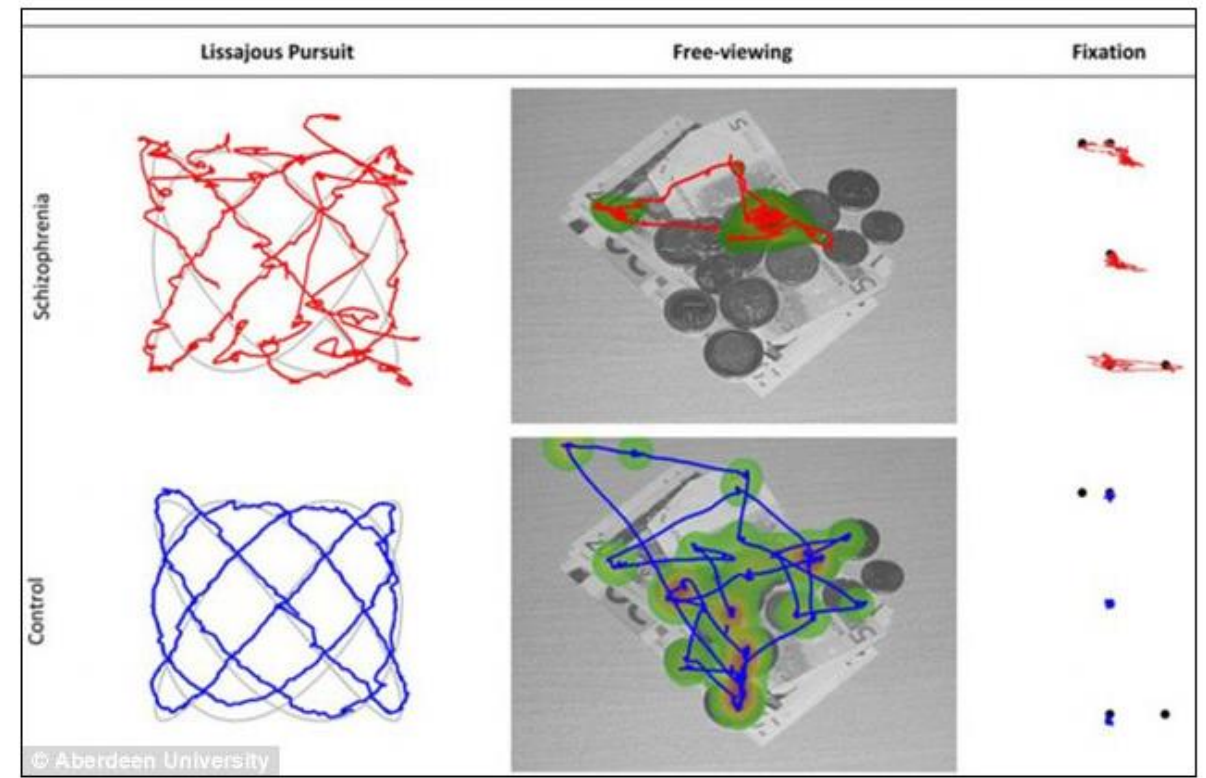
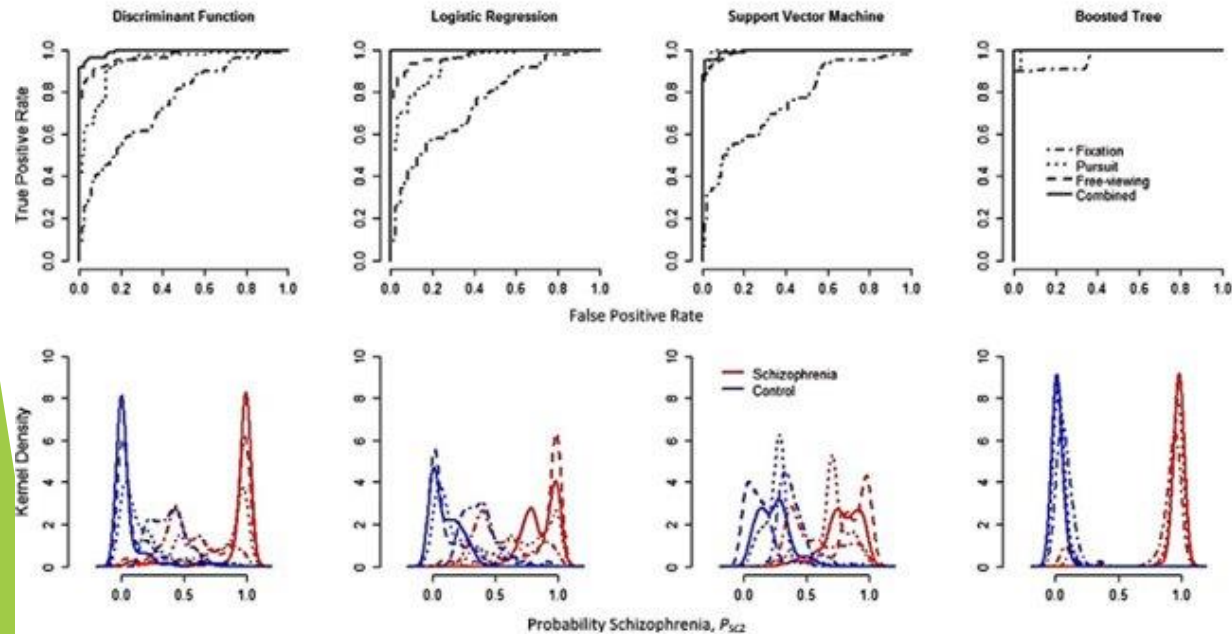


Why eye movements?

- ▶ Quick testing
- ▶ Does not require reading ability / special skills
- ▶ No expert needed (third world countries)
- ▶ Difficult to fake?
- ▶ Unconscious?
- ▶ May detect problems early

Tasks

- Smooth pursuit
- Free viewing
- Fixation



Measure

SNR-x
RMSE-x
Gain-x
SNR-y
RMSE-y
Gain-y
FixNum
FixDur
SacNum
SacDur
SacAmp
SacAVel
SacPVel

Measure

FixNum
FixDur
SacNum
SacDur
SacAmp
SacAVel
SacPVel
SPL
Dispersion

Measure

Single
FixNum
FixDur
SacNum
SacAmp
SPL
Distracter
FixNum
FixDur
SacNum
SacAmp
SPL

Benson et al. (2012). *Biological psychiatry*, 72(9), 716-724.

SACCADE Diagnostics

► Alumni

▼ Case Studies

Bellrock Technology Ltd

Chromacity Ltd

ClinSpec Dx

Elasmogen Ltd

EnteroBiotix

Estendio

Lingo Flamingo

MicroSense Technologies Ltd

MindMate

novosound

Orrin Equestrian Ltd

Pick Protection Ltd

Pop Up! Scotland

Razorbill Instruments

Robotical Ltd

SACCADE Diagnostics

Shot Scope

SACCADE Diagnostics

Madhu Nair & Philip Benson

University of Aberdeen

SACCADE Diagnostics, a spin-out from the University of Aberdeen, has devised a rapid eye-movement test called SaccScan that can help medical professionals diagnose a range of psychiatric disorders, such as schizophrenia, bipolar disorder and major depression within just 30 minutes. It is non-invasive, affordable and easy to administer, allowing non-specialists to operate it with minimal training.

The academic founders, Philip Benson and David St Clair, teamed up with Madhu Nair, who took on the role of commercial champion and CEO. Together they rose to the Challenge in 2013 and ended up winning the top Converge prize!

“Converge Challenge provided us with an incredible opportunity to stress test our business plan at the right time in our spin out journey, develop entrepreneurial thinking and benefit from high-level networks.”



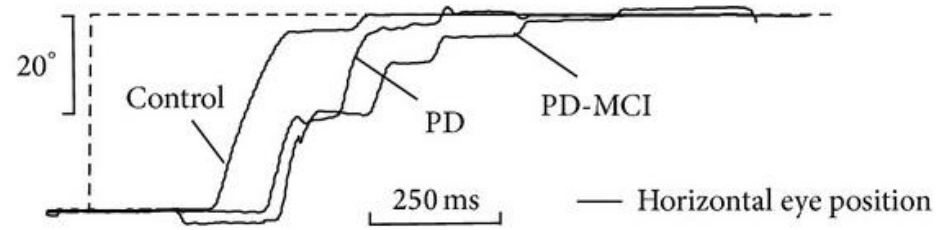
<https://portal.convergechallenge.com/alumni/case-studies/saccade-diagnostics/>

Examples of classifications

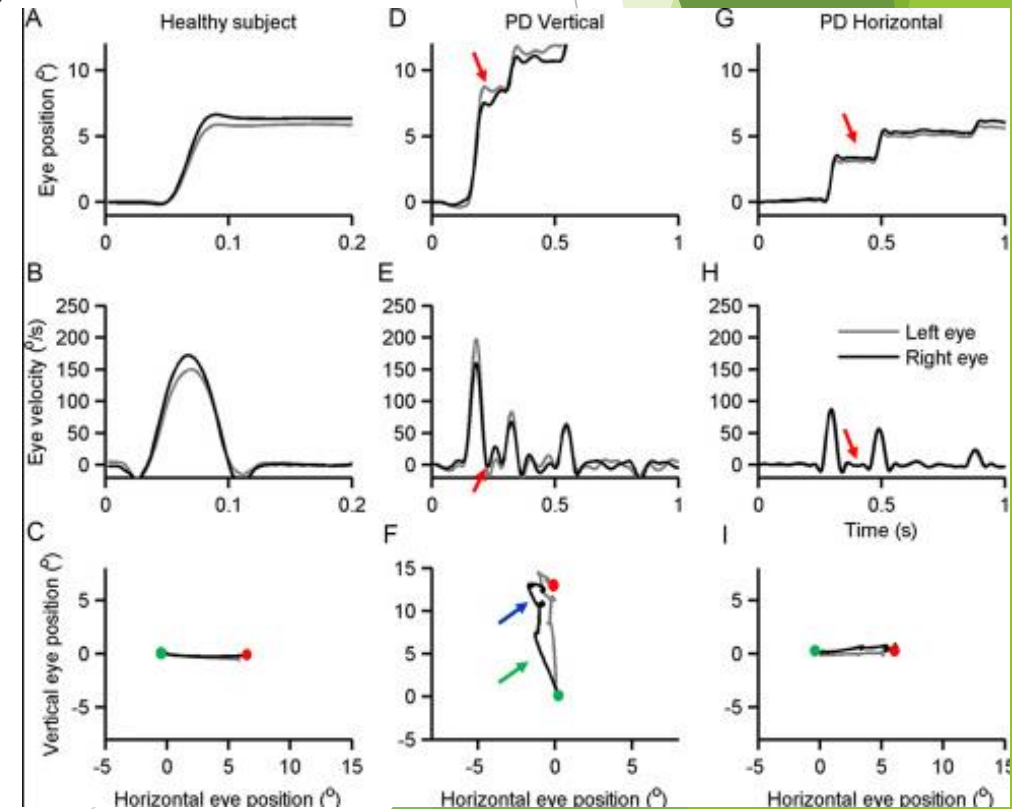
- ▶ Alzheimer's disease
- ▶ Parkinson's disease
- ▶ Eating disorders
- ▶ Expert and novice surgeons
- ▶ Sex offenders

Parkinson's disease (PD)

- ▶ Multi step saccades most prominent eye movement feature
- ▶ "good sensitivity (87%) and excellent specificity (96%)"

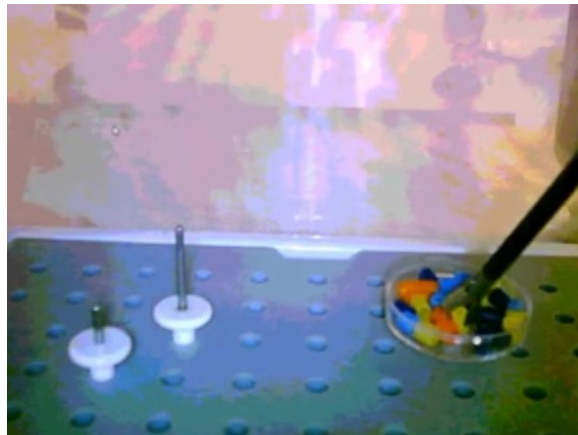


Blekher et al.(2009). *Parkinsonism & related disorders*, 15(7), 506-510.



Expert and novice surgeons

- ▶ Eye-hand coordination in key-hole surgery
- ▶ Decision on who to assign which complexity of cases
- ▶ Decision on who to start training as a surgeon



Measuring eye movements

Measuring eye movements

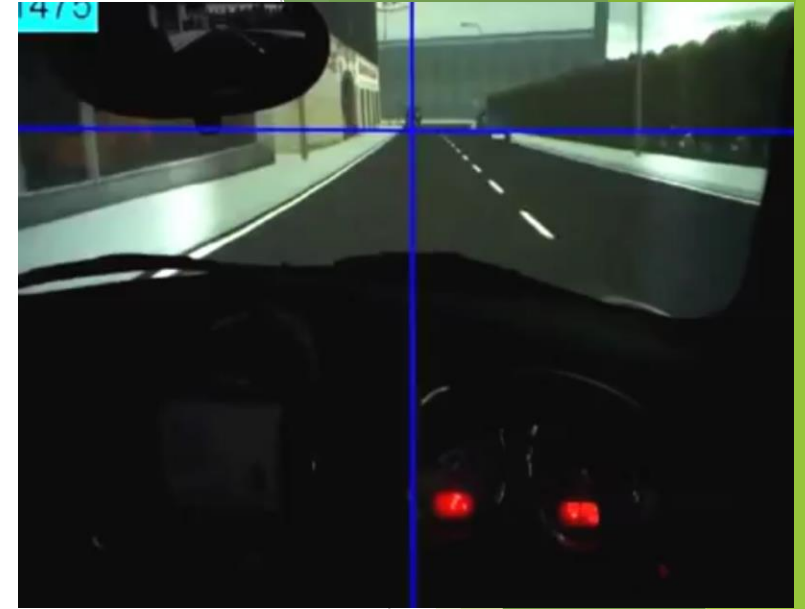
- ▶ Desktop eye trackers
 - ▶ Highly accurate
 - ▶ More accurate with head fixation
 - ▶ Present images / videos / text



https://www.youtube.com/watch?v=6Mm03_cvXM4

Measuring eye movements

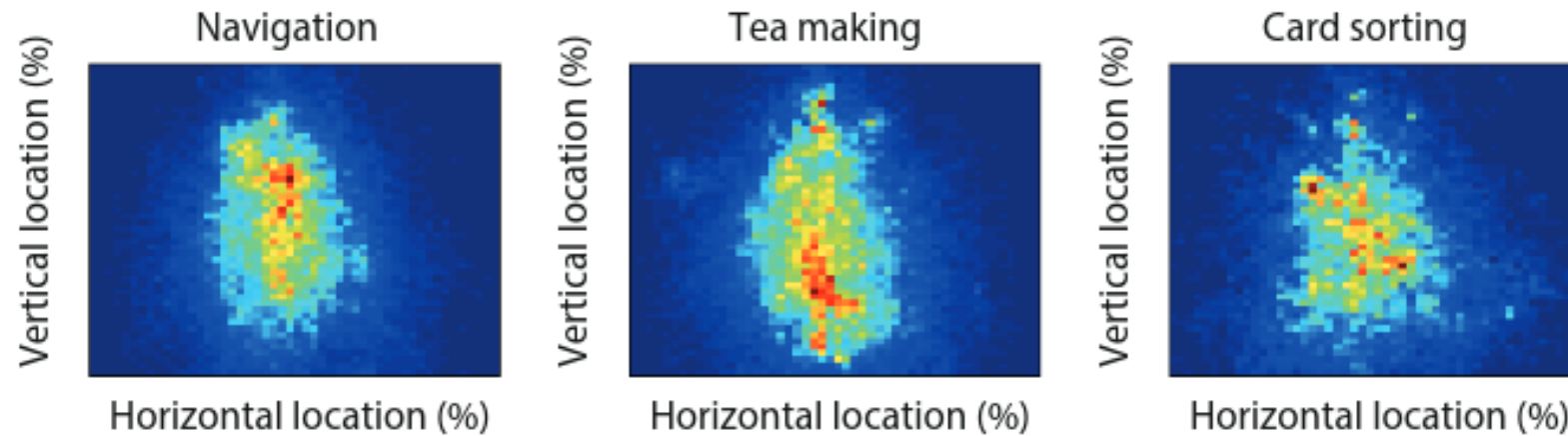
- Mobile eye trackers
 - Head-mounted camera
 - Less accurate
 - Analysis: Image varies per participant



https://www.youtube.com/watch?v=6Rtg_pcRVig&t=1s

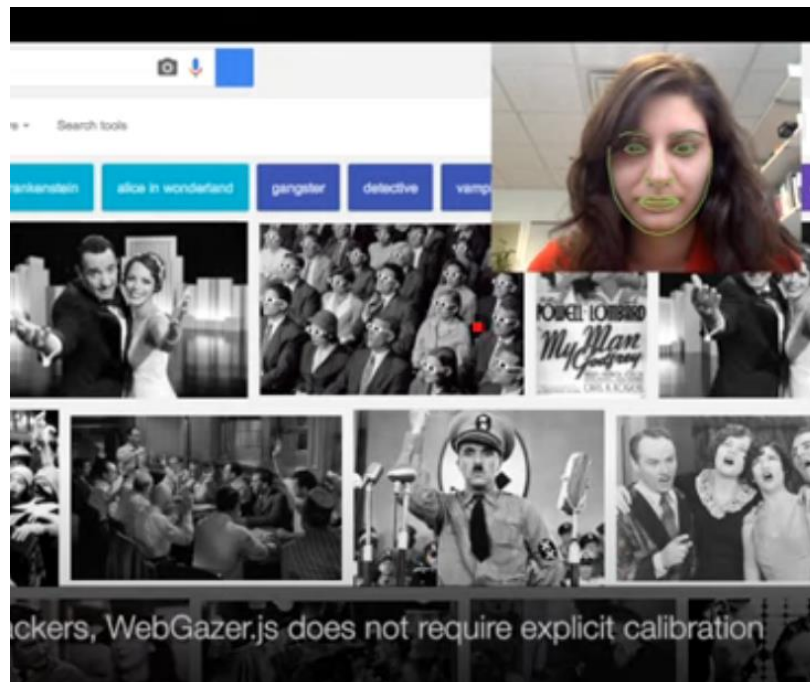
Eye tracking without eye tracker?

- ▶ Google glass?
 - ▶ Central bias



Eye tracking without eye tracker?

► Webcam?

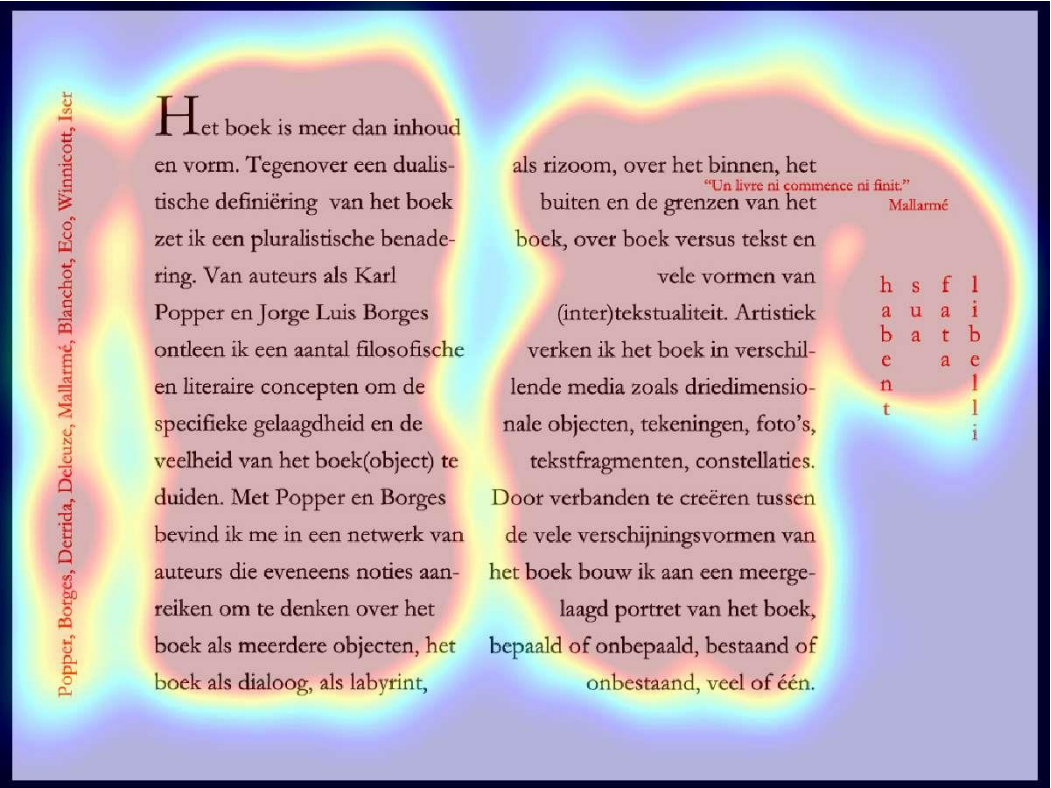


Eye movement analysis

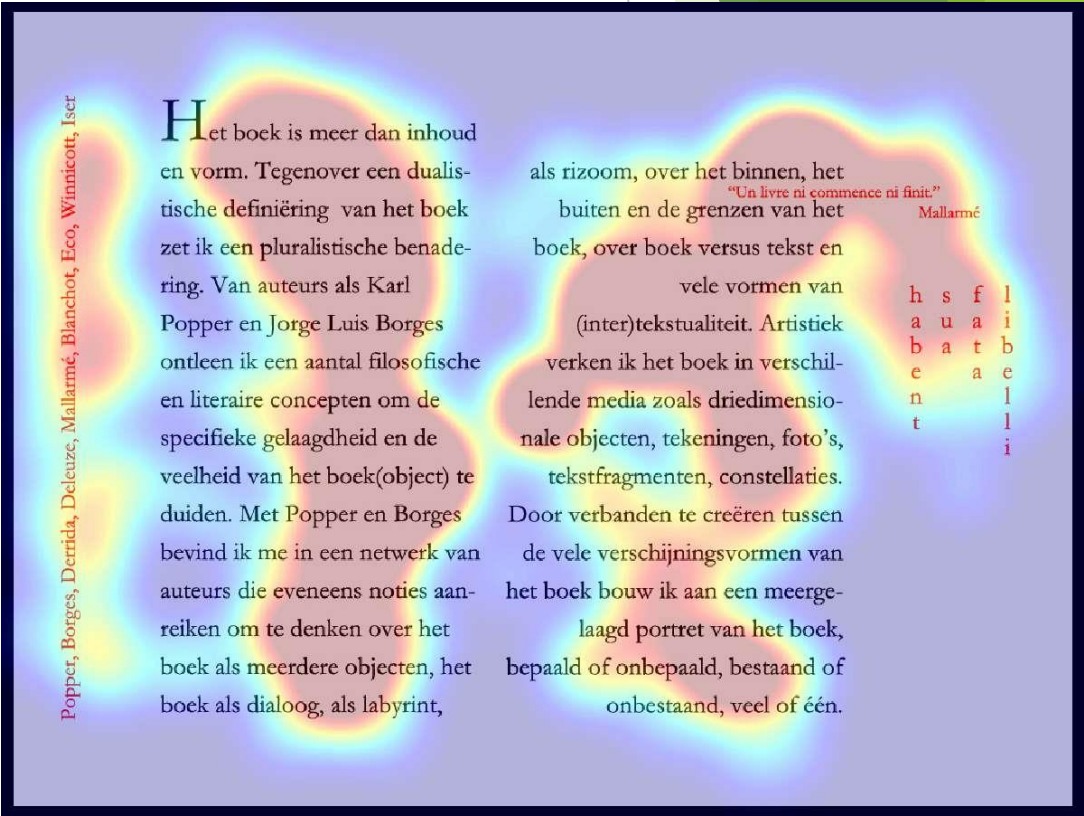
Heatmaps



"Just read"

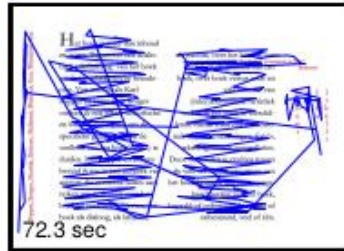


"Count parentheses"

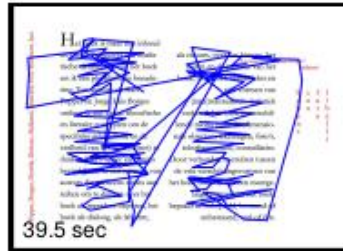


Scanpaths

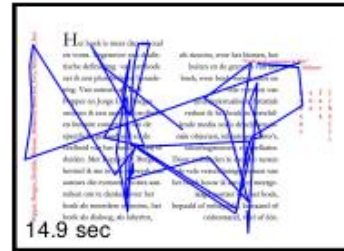
1. Just look



2. How often "book"?



3. How many parentheses?



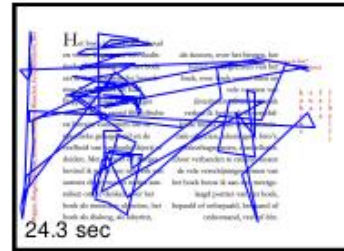
4. Which languages?



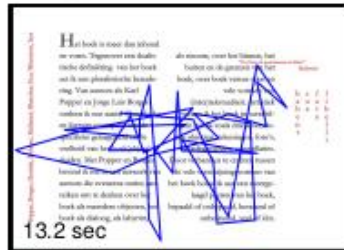
5. Lines starting?



6. Authors multiple times?



7. Organization of columns?



8. "Lotgevallen"?

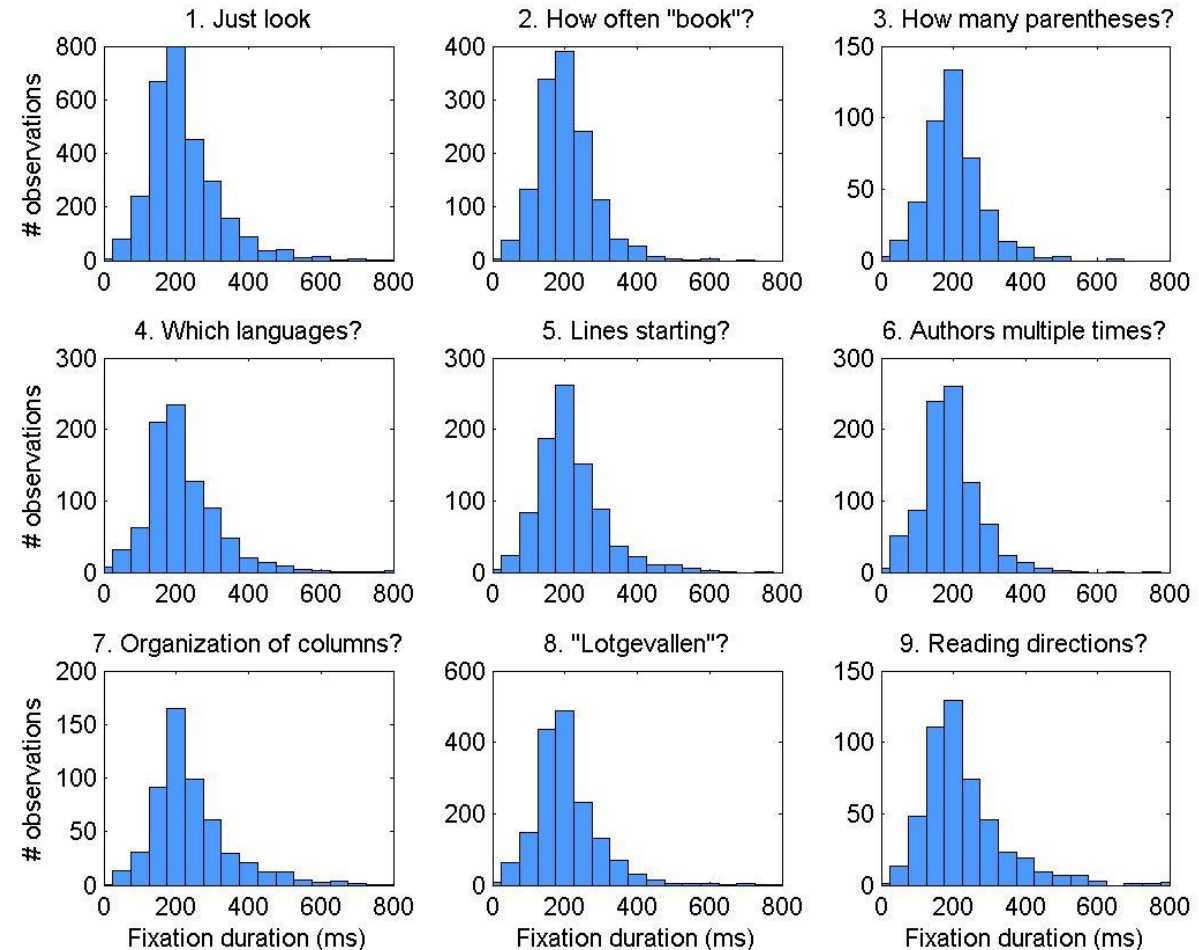
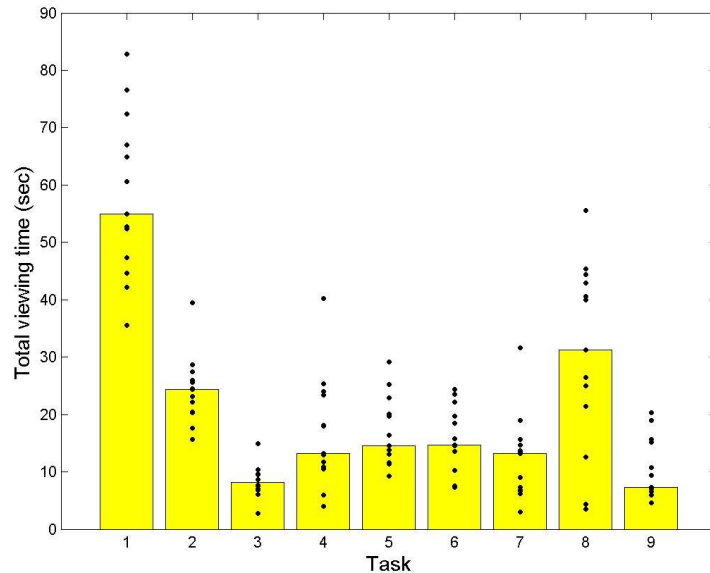


9. Reading directions?



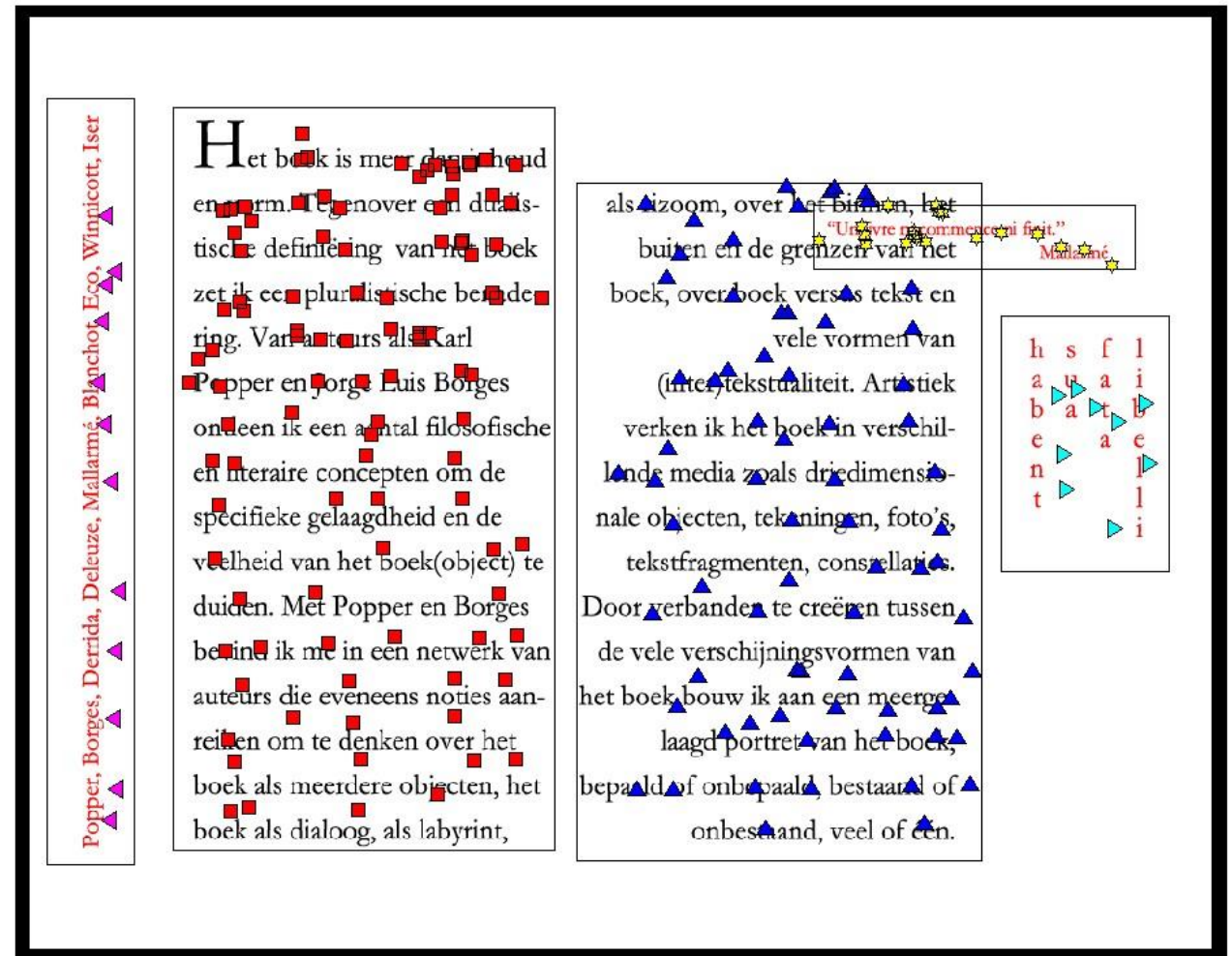
General eye movement properties

- Fixation durations
- Saccade amplitudes
- Total viewing time

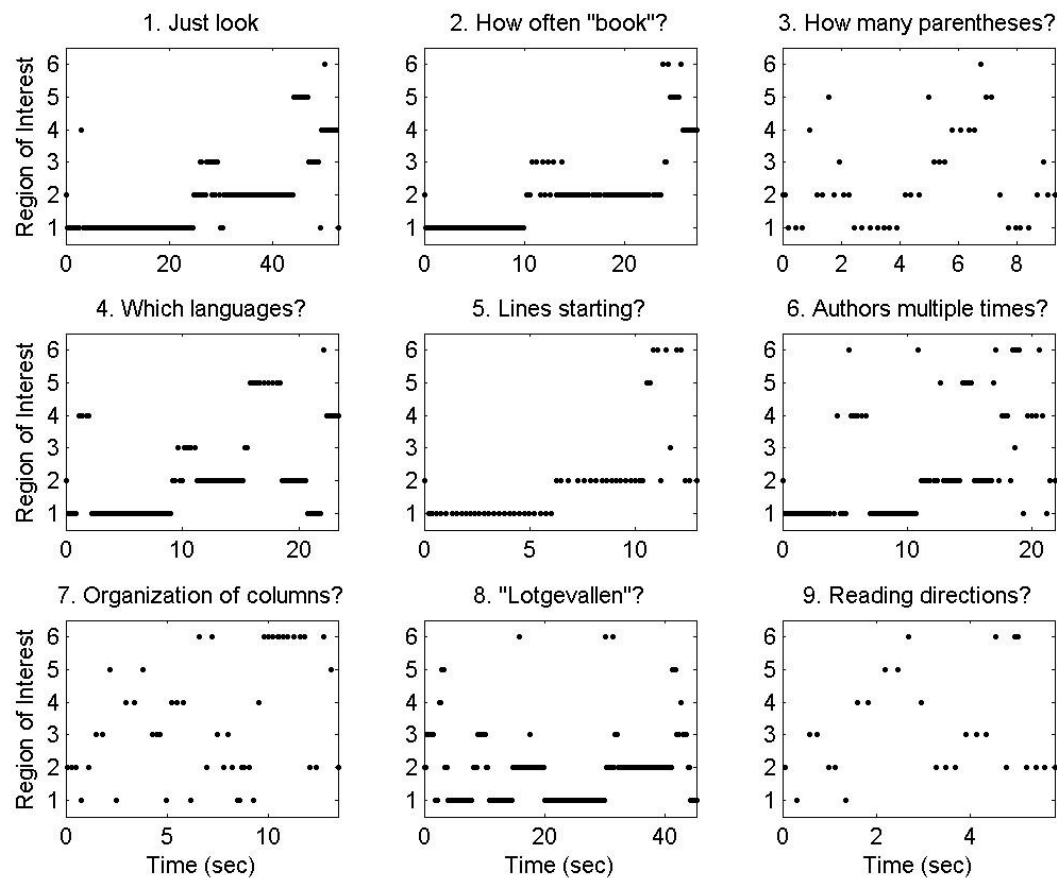
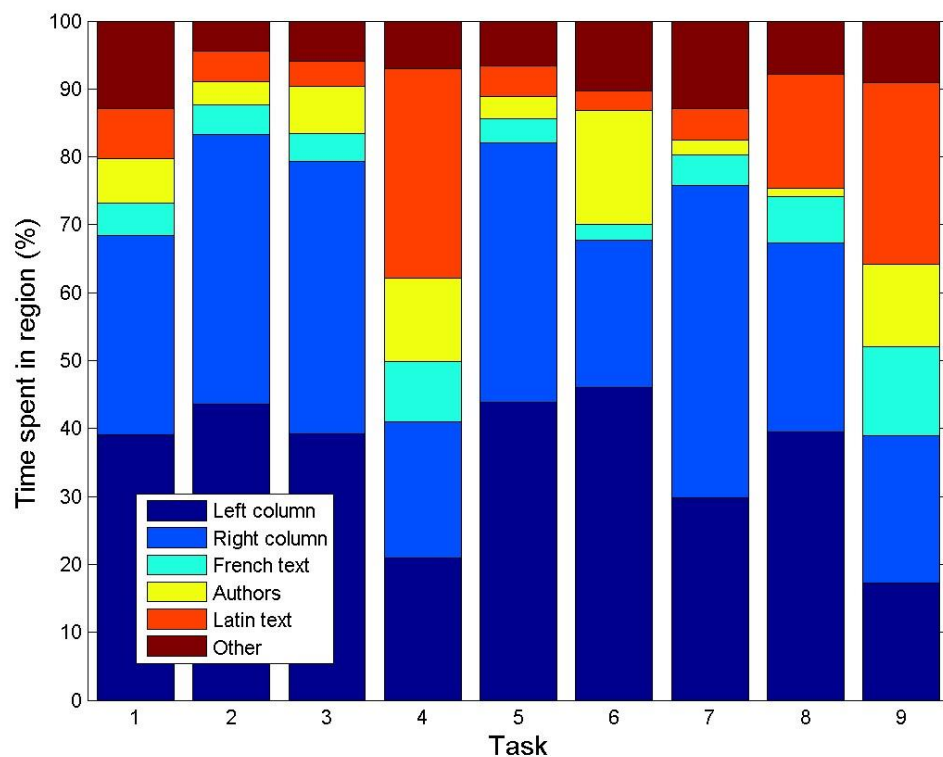


Regions of interest (ROIs) analysis

- Dwell times
- Refixations
- Number of fixations



Regions of interest (ROIs) analysis

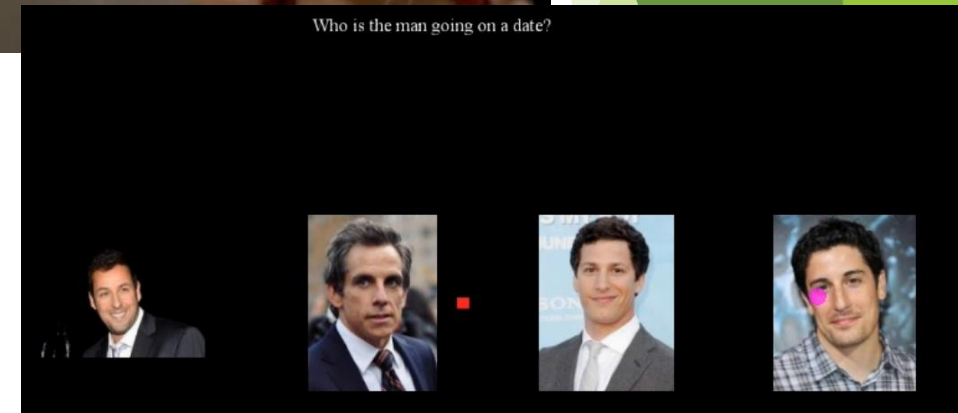


The background features abstract, overlapping green geometric shapes, primarily triangles and polygons, in various shades of green, creating a modern, layered effect on the right side of the slide.

Current study

Dynamic stimuli

- ▶ More ecologically valid
- ▶ Not used often, because of labour intensive nature for analysing data



Analysis dynamic stimuli

- ▶ Dynamic heatmaps
- ▶ General eye movement properties
- ▶ ROI analysis often more complicated:
 - ▶ Frame by frame annotation of ROIs (computer vision may help)
 - ▶ Subjective (eye-of-the-beholder / researcher)
 - ▶ Not always clear for all types of stimuli (e.g., surgical images)



Study aim



- ▶ Develop method, that:
 - ▶ Detects group differences in eye movements
 - ▶ Helps to select relevant stimuli / sections of videos
 - ▶ Is easy to apply
 - ▶ Does not require (extensive) manual annotation
 - ▶ Is data driven
- ▶ Validate method

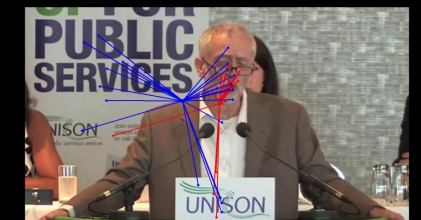
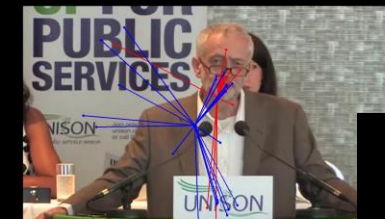
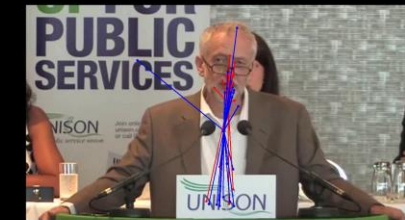
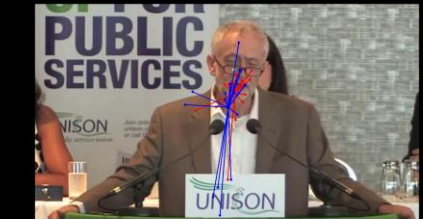
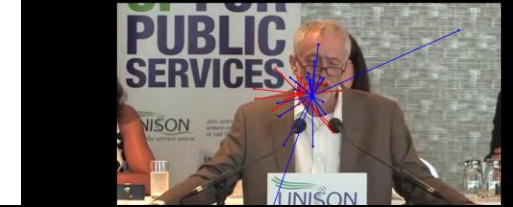
Political orientation: Methods

- ▶ Student sample (40 participants)
 - ▶ No expert surgeons / offenders / patients needed
 - ▶ Ethics: waste of valuable time if unsuccessful
- ▶ Group difference
 - ▶ Political orientation (left-wing / right-wing)
- ▶ Stimuli: Videos of politicians (4 politicians; 20 videos each)
- ▶ Eye tracking: Tobii T60 with head stabilization



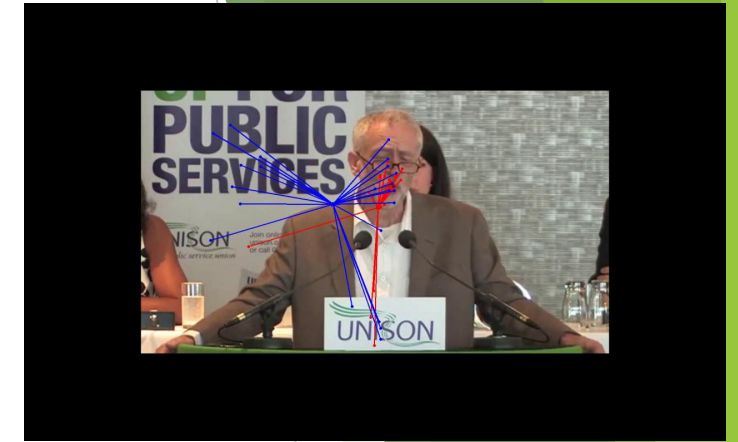
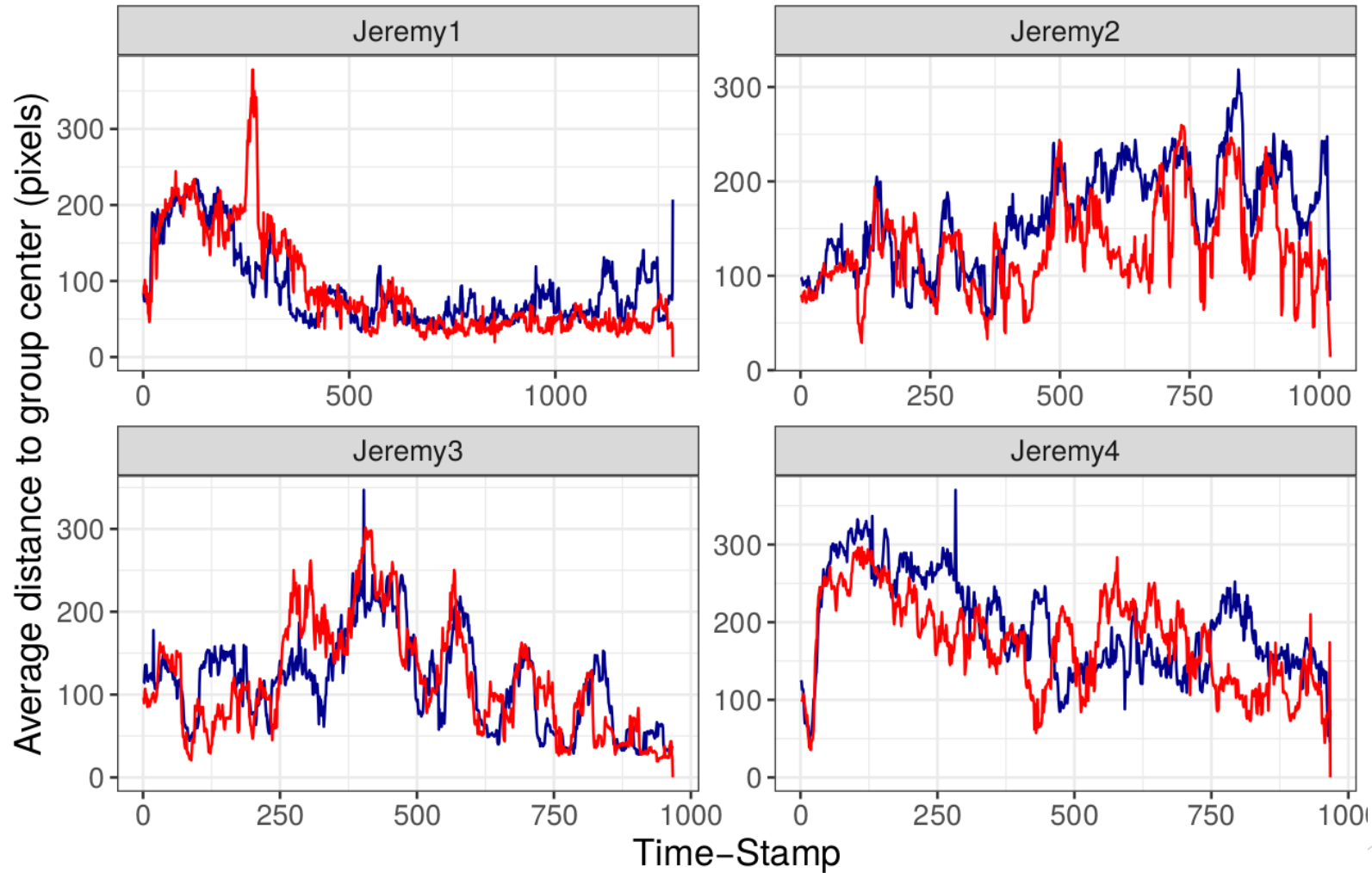
Method: General idea

- ▶ Compare x- y- locations separately between groups
- ▶ Compare distance to group center



Traces

— Conservative — Labour

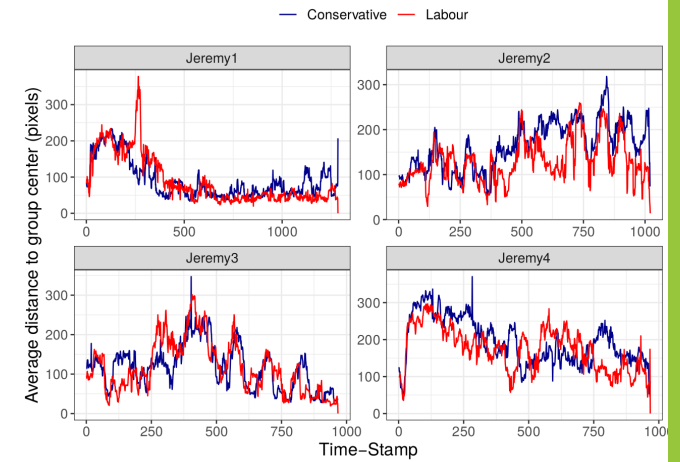


T-tests

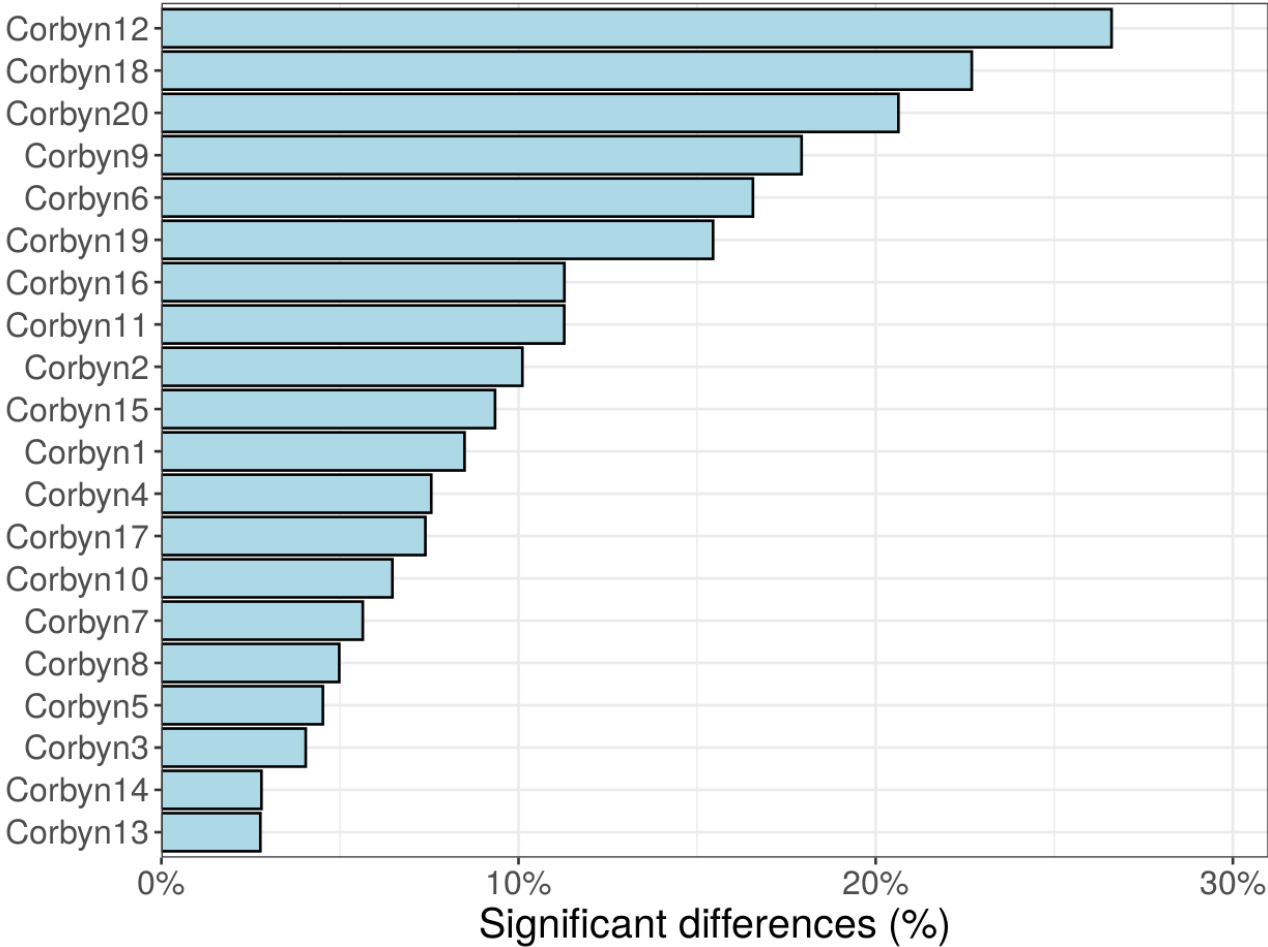
	A	B	C	D	E	F
1	Su	Video	<u>Idx</u>	<u>Xloc</u>	<u>Yloc</u>	<u>Group</u>
2	1	Jeremy1	1	891	498	1
3	1	Jeremy1	2	891	499	1
4	1	Jeremy1	3	897	497	1
5	1	Jeremy1	4	894	503	1
6	1	Jeremy1	5	892	496	1
7	1	Jeremy1	6	895	496	1
8	1	Jeremy1	7	987	523	1
9	1	Jeremy1	8	974	517	1
10	1	Jeremy1	9	977	521	1
11	1	Jeremy1	10	978	520	1
12	1	Jeremy1	11	971	515	1
13	1	Jeremy1	12	979	519	1
14	1	Jeremy1	13	980	514	1
15	1	Jeremy1	14	977	522	1
16	1	Jeremy1	15	968	518	1
17	1	Jeremy1	16	973	519	1
18	1	Jeremy1	17	977	517	1
19	1	Jeremy1	18	979	517	1
20	1	Jeremy1	19	977	514	1
21	1	Jeremy1	20	980	519	1
22	1	Jeremy1	21	977	514	1



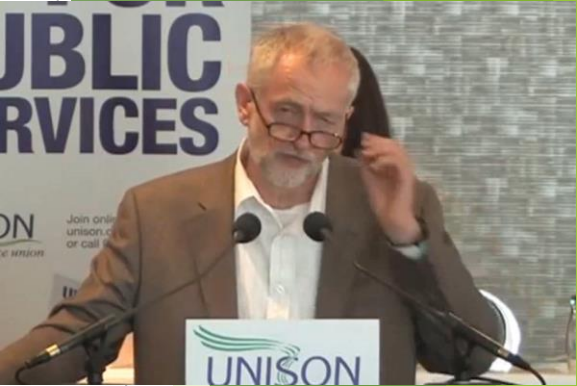
	A	B	C	D
1	<u>Idx</u>	<u>Video</u>	<u>p_value</u>	<u>sign</u>
2	1	Jeremy1	0.956674521666634	0
3	1	Jeremy10	0.972322952696409	0
4	1	Jeremy11	0.764133685976754	0
5	1	Jeremy12	0.449315741688586	0
6	1	Jeremy13	0.360444220823007	0
7	1	Jeremy14	0.355173567150952	0
8	1	Jeremy15	0.615813353780441	0
9	1	Jeremy16	0.371745187858207	0
10	1	Jeremy17	0.251957056112398	0
11	1	Jeremy18	0.439988539492951	0
12	1	Jeremy19	0.0839527543026626	0
13	1	Jeremy2	0.240412035855281	0
14	1	Jeremy20	0.569165985524795	0
15	1	Jeremy3	0.932504001028139	0
16	1	Jeremy4	0.459350686169378	0
17	1	Jeremy5	0.75161422537374	0
18	1	Jeremy6	0.885787996176923	0
19	1	Jeremy7	0.136373649379256	0
20	1	Jeremy8	0.511732738334228	0
21	1	Jeremy9	0.588069207426242	0



Compare videos



Corbyn12



Corbyn13



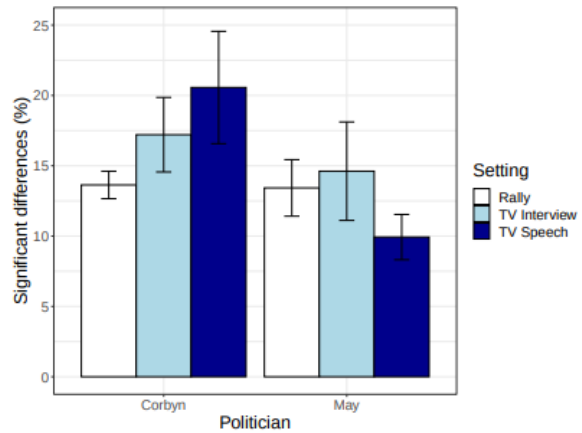
Causes differences?

- ▶ Inspect sections of videos with 'significant' differences
- ▶ Inspect videos with 'significant' differences

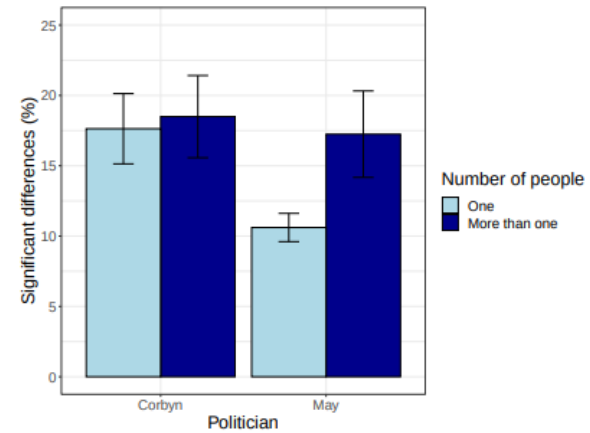


Video aspects

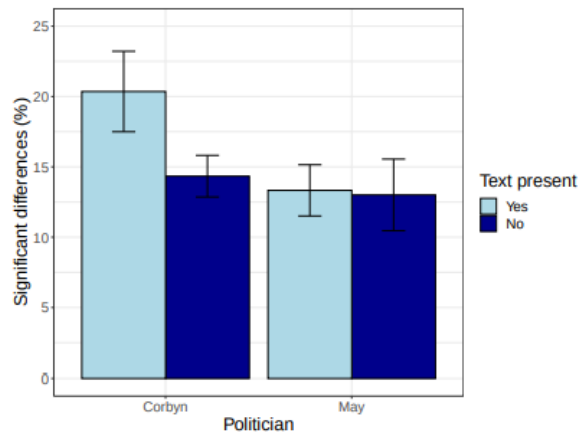
(a) Setting



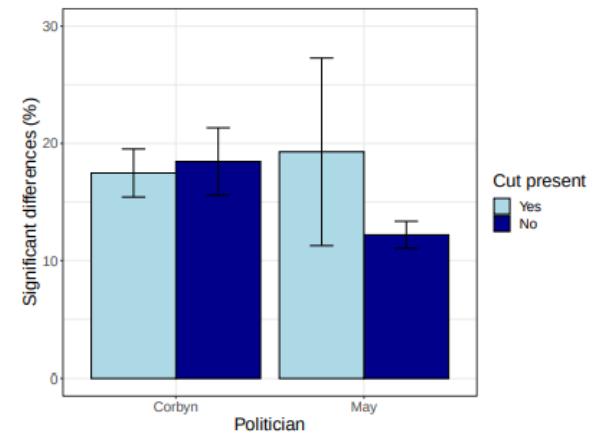
(b) Number of people



(c) Text present



(d) Cut present



Average viewing location

Labour



Non-Labour



Labour



Non-Labour



Labour



Non-Labour



Labour

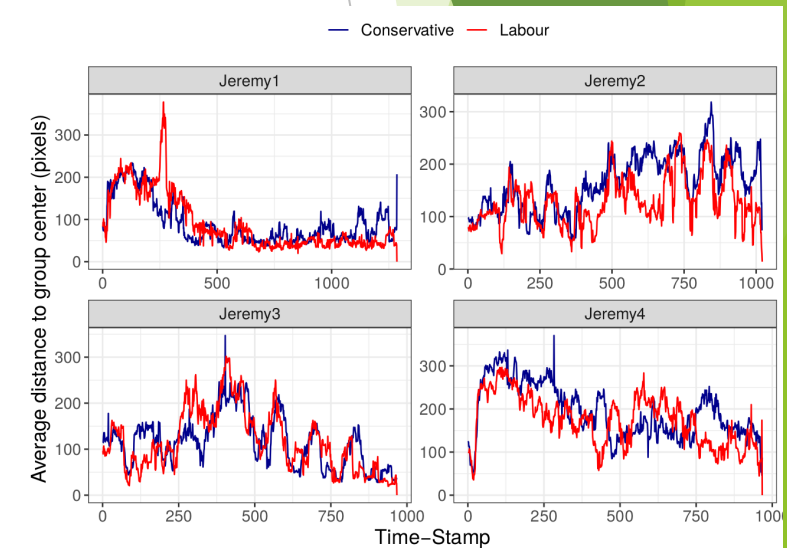
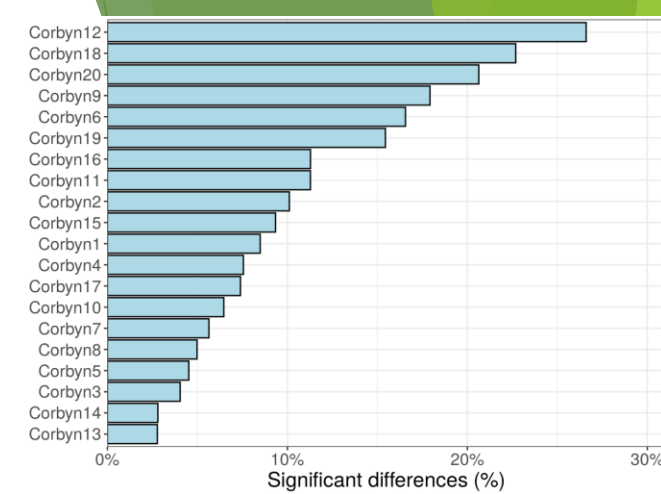


Non-Labour

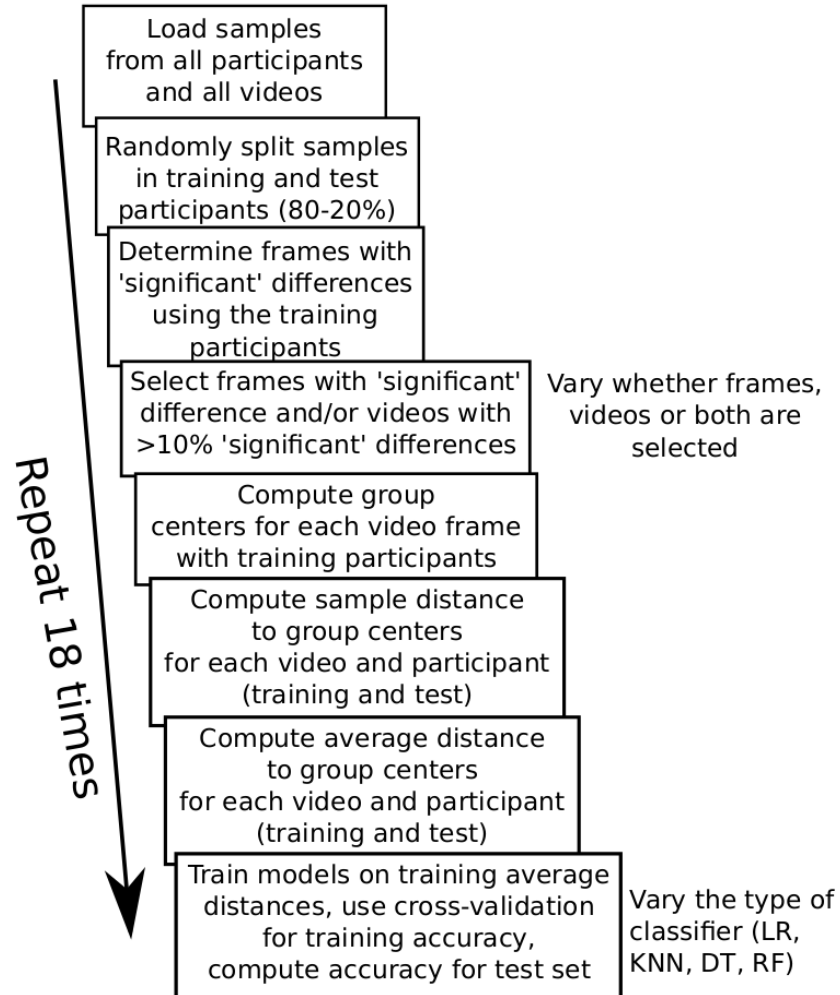


Predict group membership

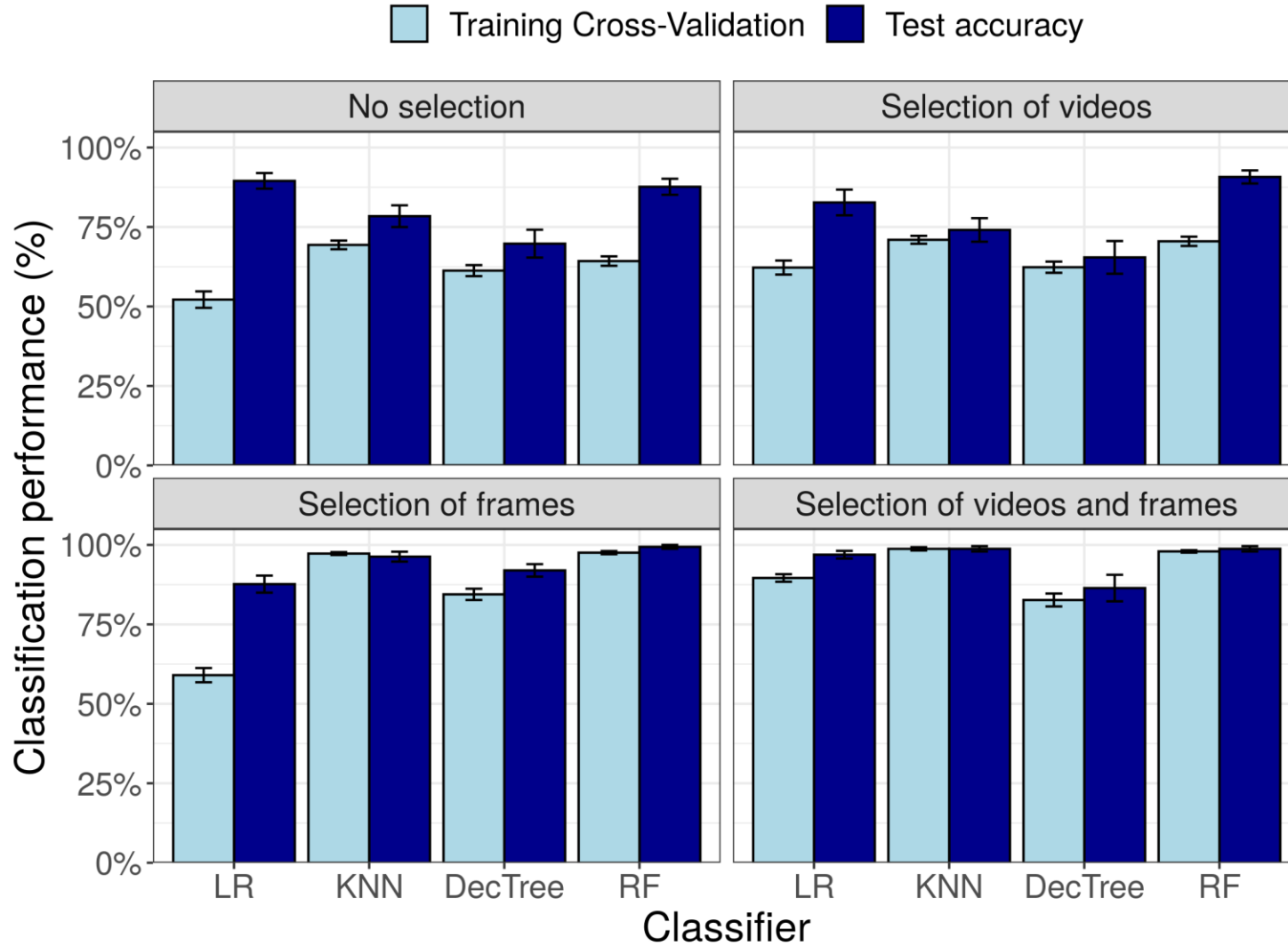
- ▶ Use the 2 UK-based politicians (Corbyn, May)
- ▶ Split data in training and test set
- ▶ Compute average distance to group center per video (training)
- ▶ Apply filters:
 - ▶ No filter
 - ▶ Select videos (high % difference)
 - ▶ Select frames (only 'significant')
 - ▶ Select videos and frames
- ▶ Train classifier
- ▶ Compute performance on training set (cross-validation) and test set (confusion matrix / accuracy)



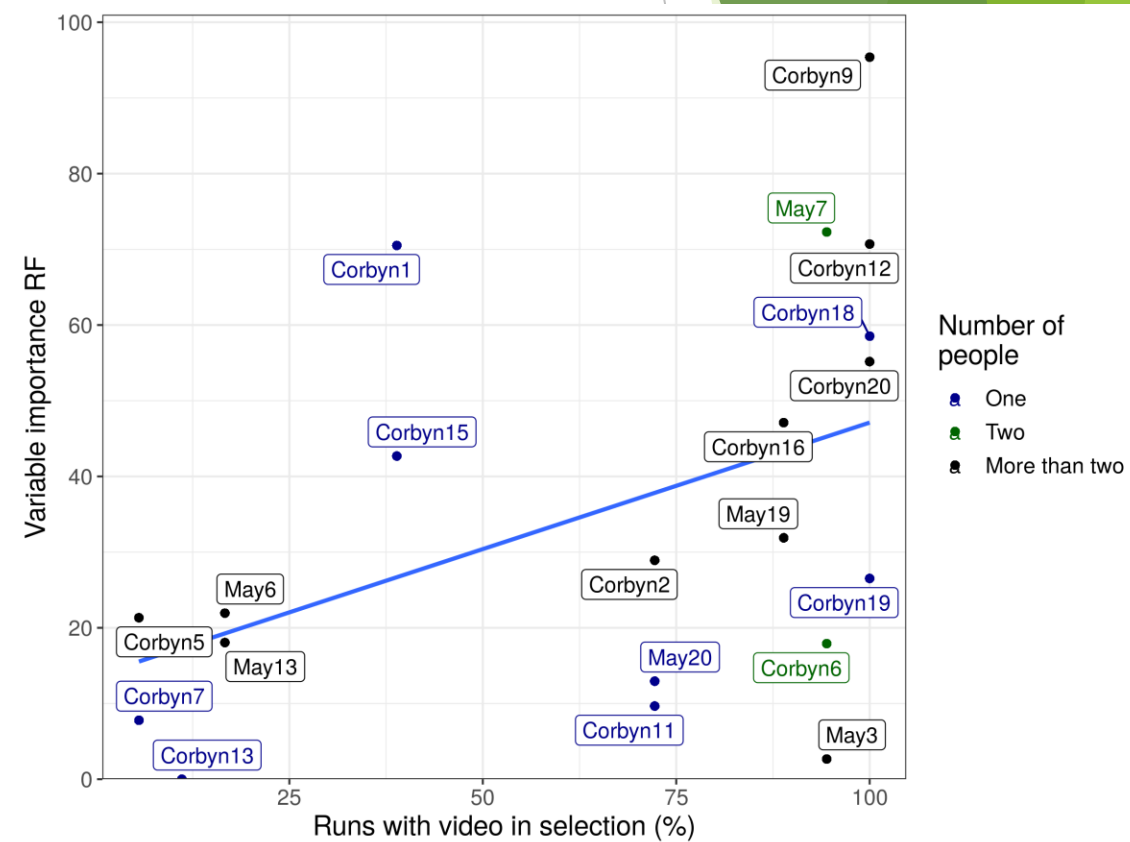
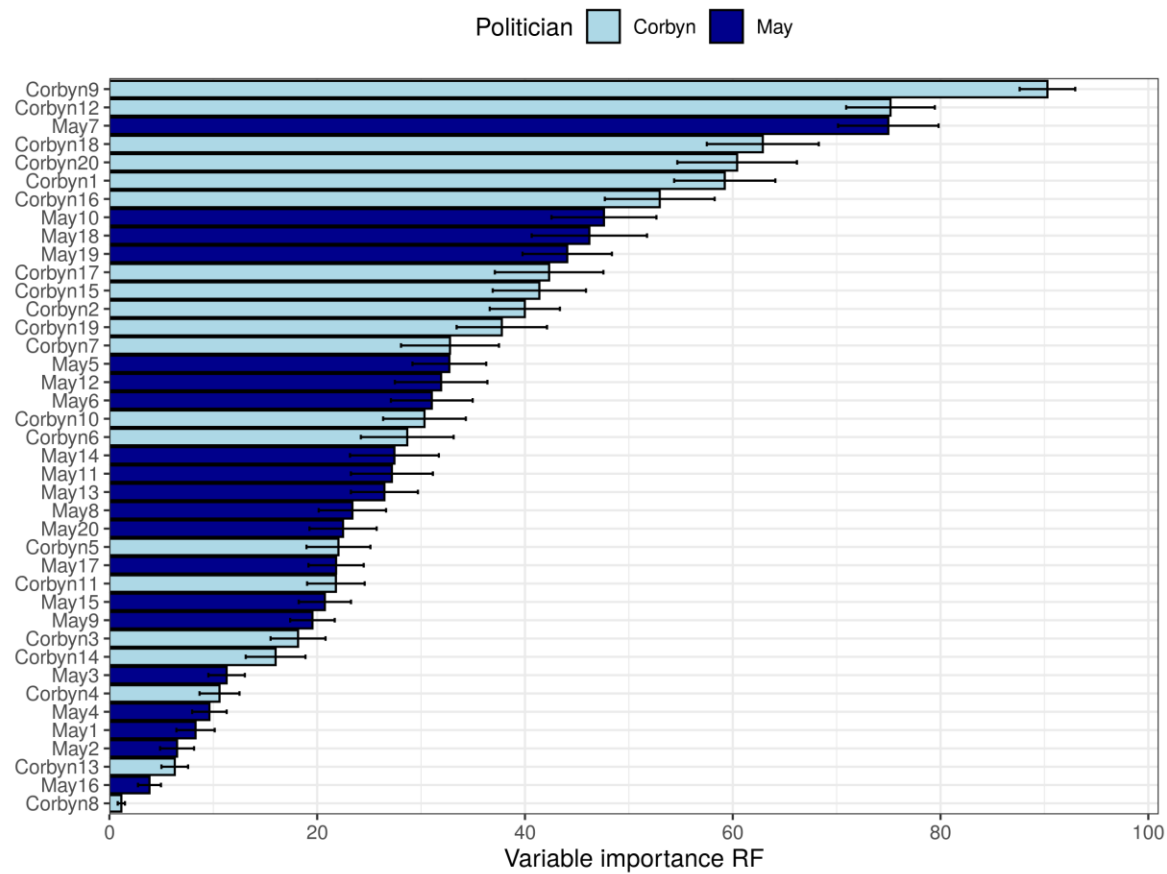
Predict group membership



Results



Variable importance



Summary

- ▶ New method based on simple t-tests
- ▶ Can find videos with large group differences
- ▶ Can find frames with large group differences
- ▶ Can predict group membership
- ▶ Group membership seems related to fixating mouth (conservatives) or eyes (labour)
- ▶ Effects larger for left-wing politician



Future directions

- ▶ Test method with other types of groups
- ▶ Create videos highlighting 'significant' frames
- ▶ Better understand machine learning predictions
- ▶ Use computer vision to automatically annotate regions of interest
- ▶ Test the method on other types of behavioral data (e.g., mouse clicks, webpage scrolling, activity trackers)
- ▶ Use knowledge about oculomotor system
- ▶ Ethics

