

Data driven group comparisons of eye fixations to dynamic stimuli

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#### 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



by checking their gaze (posed by model)

# 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.

https://www.dailymail.co.uk/health/article-2225792/New-100-accurate-test-diagnoseschizophrenics.html https://www.scotsman.com/news/eye-test-gives-flicker-hope-psychiatric-patients-1470640

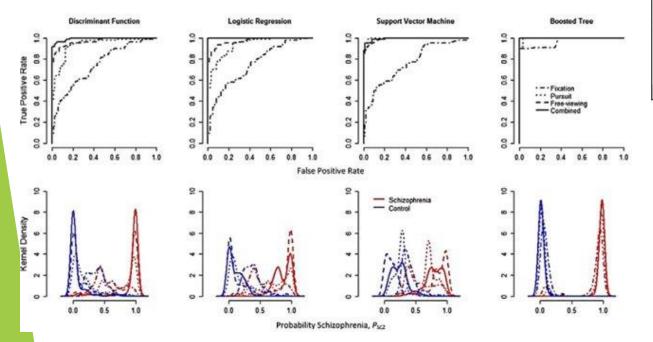


#### Why eye movements?

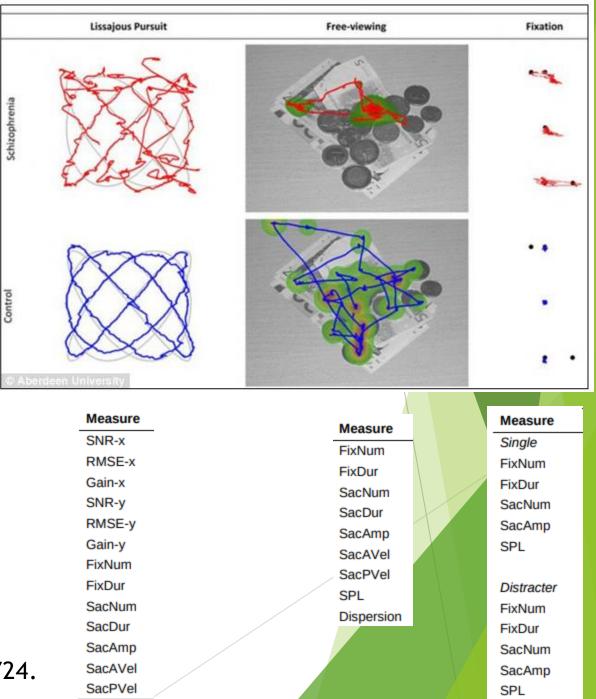
- Quick testing
- Does not require reading ability / special skills
- No expert needed (third world countries)
- Difficult to fake?
- Unconscious?
- May detect problems early

#### Tasks

- Smooth pursuit
- Free viewing
- Fixation



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



#### **SACCADE** Diagnostics

#### Alumni

#### Case Studies

Bellrock Technology Ltd University of Aberdeen Chromacity Ltd ClinSpec Dx Elasmogen Ltd EnteroBiotix Estendio Lingo Flamingo MicroSense Technologies Ltd MindMate novosound **Orrin Equestrian Ltd** prize! Pick Protection Ltd Pop Up! Scotland Razorbill Instruments Robotical Ltd SACCADE Diagnostics Shot Scope

#### SACCADE Diagnostics

Madhu Nair & Philip Benson

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

"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."



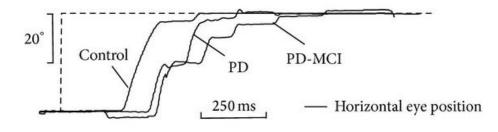
https://portal.convergechallenge.com/alumni/case-studies/saccadediagnostics/

#### Examples of classifications

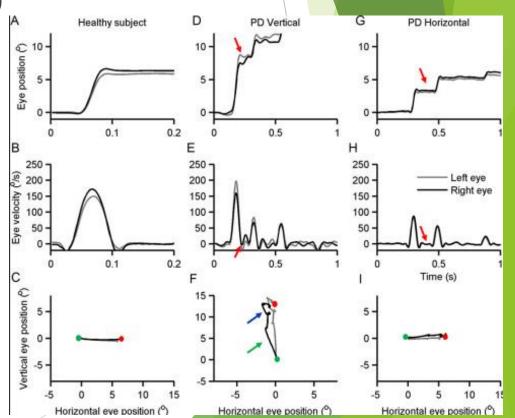
- Azheimer's disease
- Parkinson's disease
- Eating disorders
- Expert and novice surgeons
- Sex offenders

#### 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

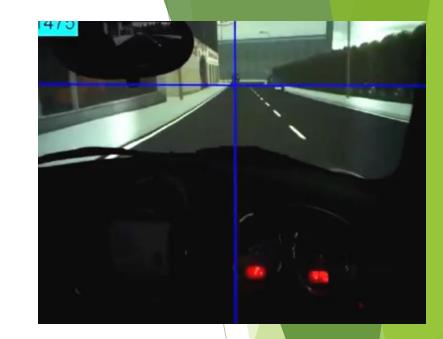
- Desktop eye trackers
  - Highly accurate
  - More accurate with head fixation
  - Present images / videos / text





#### Measuring eye movements

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

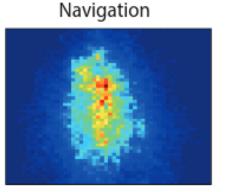




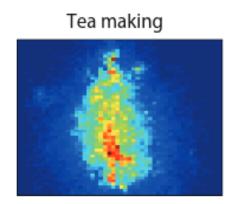
#### Eye tracking without eye tracker?

- Google glass?
  - Central bias





Horizontal location (%)

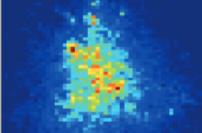


Vertical location (%)

Horizontal location (%)

Card sorting

Vertical location (%)

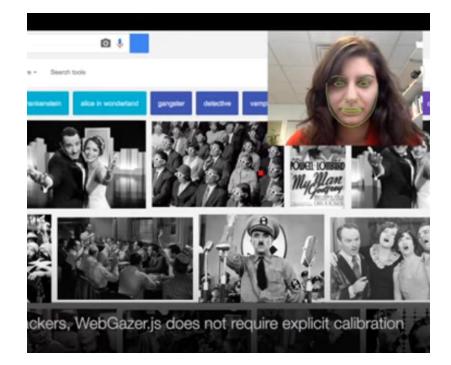


Horizontal location (%)



#### Eye tracking without eye tracker?

Webcam?



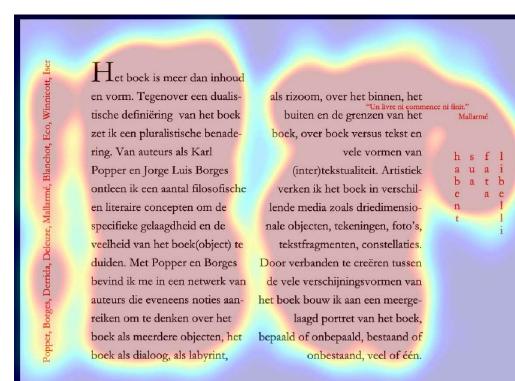
https://www.youtube.com/watch?v=NRLlRh2apA8&t=32s



# Eye movement analysis

#### Heatmaps

#### "Just read"



#### "Count parentheses"

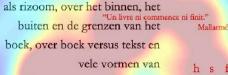
rmé, Blanchot, Eco, Winnicott,

Malla

Deleuze,

opper, Borges, Derrida,

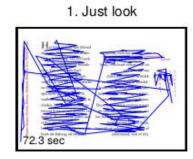
Het boek is meer dan inhoud en vorm. Tegenover een dualistische definiëring van het boek zet ik een pluralistische benadering. Van auteurs als Karl Popper en Jorge Luis Borges ontleen ik een aantal filosofische en literaire concepten om de specifieke gelaagdheid en de veelheid van het boek(object) te duiden. Met Popper en Borges bevind ik me in een netwerk van auteurs die eveneens noties aanreiken om te denken over het boek als meerdere objecten, het boek als dialoog, als labyrint,



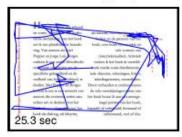
(inter)tekstualiteit. Artistiek verken ik het boek in verschillende media zoals driedimensionale objecten, tekeningen, foto's, tekstfragmenten, constellaties. Door verbanden te creëren tussen de vele verschijningsvormen van het boek bouw ik aan een meergelaagd portret van het boek, bepaald of onbepaald, bestaand of onbestaand, veel of één.



#### Scanpaths



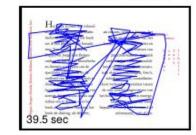
4. Which languages?



7. Organization of columns?

3.14	Le torie a race da artend	
1 :	Art tools in tool the second count. Togeneous and dually the dofiniting tan her boath its use pleasiming to he node	de secone, com los lineas, los bates es degenerai en los
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13	A	
	ales Herlingper er ber	Contraction of the second
7 In	han one to dealerst over her of all manuface officeres, and of the finiteses, of informa-	hapt of second and for cost,
13.2	sec	

2. How often "book"?



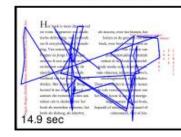
5. Lines starting?

8. "Lotgevallen"?

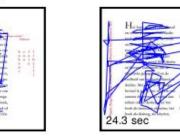
29.1 sec

40.6 sec

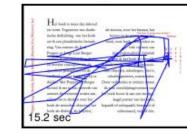
3. How many parentheses?



6. Authors multiple times?

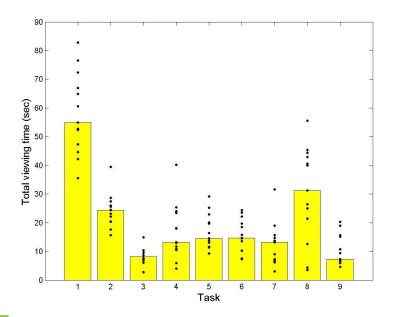


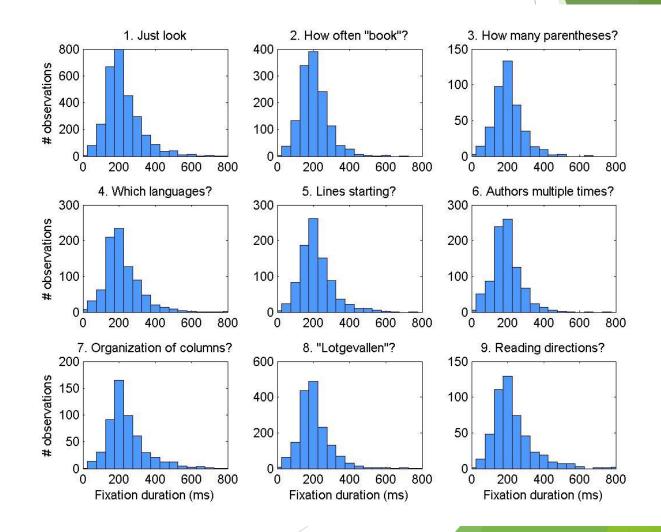
9. Reading directions?



#### General eye movement properties

- Fixation durations
- Saccade amplitudes
- ► Total viewing time



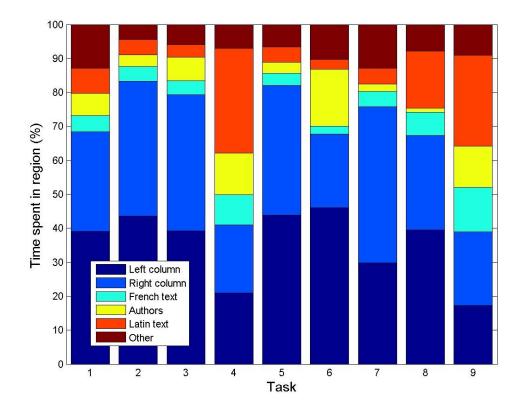


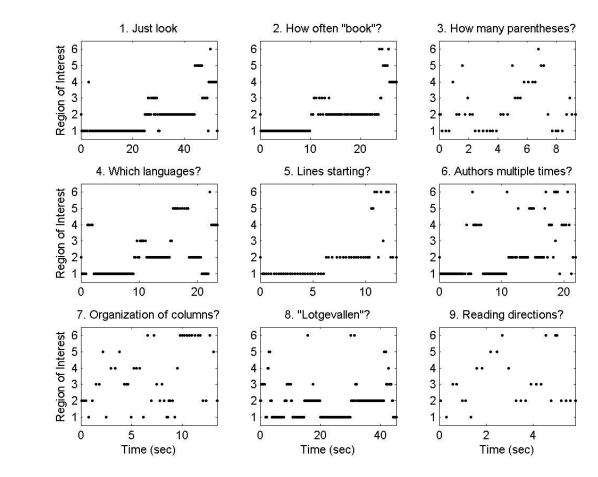
#### Regions of interest (ROIs) analysis

- Dwell times
- Refixations
- Number of fixations

Popper, Borges, Derrida, Deleuze, Mallarmé, Blanchot, Eço, Winnicott, İser Het book is mean design haud en rm. Terenover en duaisals Azoom, over hat birmon, hat buiten en de grenzen van het tische definitiong van in boek boek, overboek versas tekst en zet ik een plur is sche benaden vele vormen van ring. Var atours ale Carl hsfl Pepper en forge Luis Borges (interstekstualiteit. Artistiek ondeen ik een aantal filosofische verken ik het boek in verschila en interaire concepten om de lande media zoals driedimens n specifieke gelaagdheid en de nale objecten, tekaningen, foto's,  $\ge i$ veelheid van het boek(object) te tekstfragmenten, consrellaries. duiden. Met Popper en Borges Door verbanden te creëren tussen being ik me in een netwerk van de vele verschijningsvormen van auteurs die eveneens noties aanhet boek bouw ik aan een meergen laagd portret van het bock reilen om te denken over het boek als meerdere objecten, het bepaddof onboaald bestaatd of boek als dialoog, als labyrint, onbestand, veel of cen.

#### Regions of interest (ROIs) analysis





# Current study

#### Dynamic stimuli

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



Who is the man going on a date?



#### 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









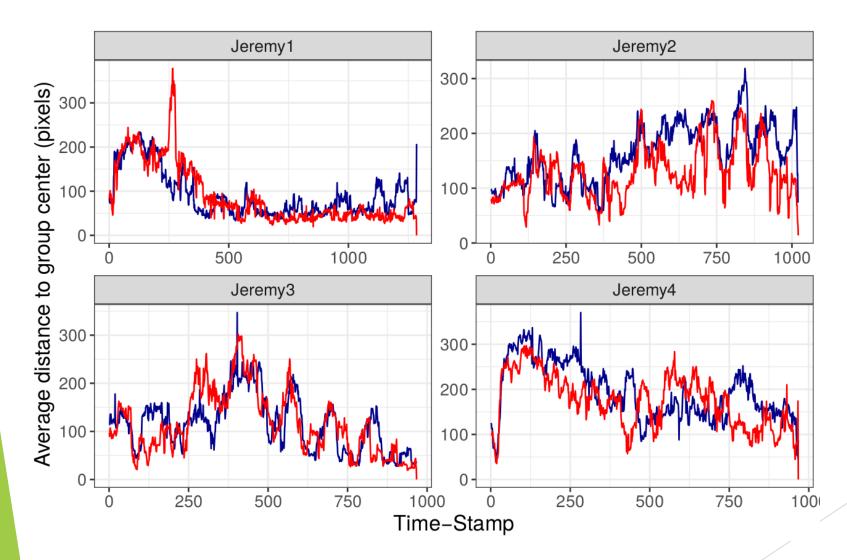


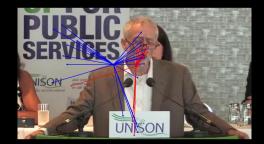






— Conservative — Labour



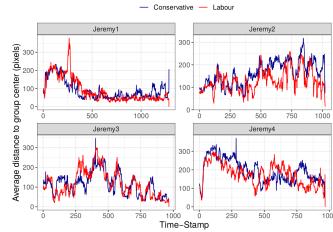




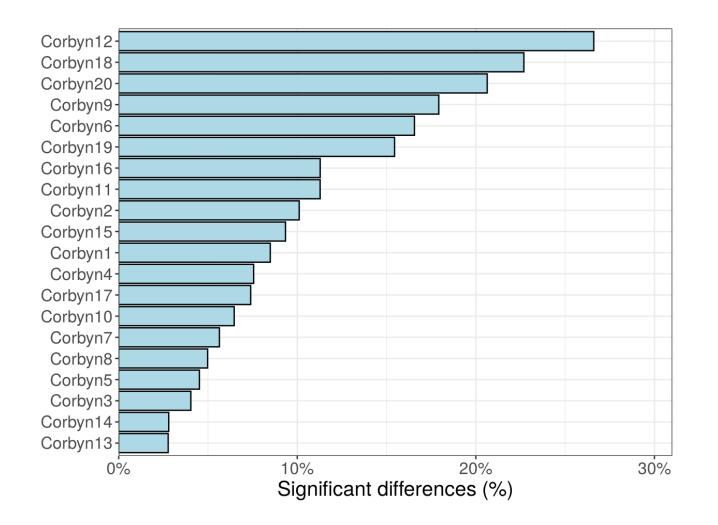
#### **T-tests**

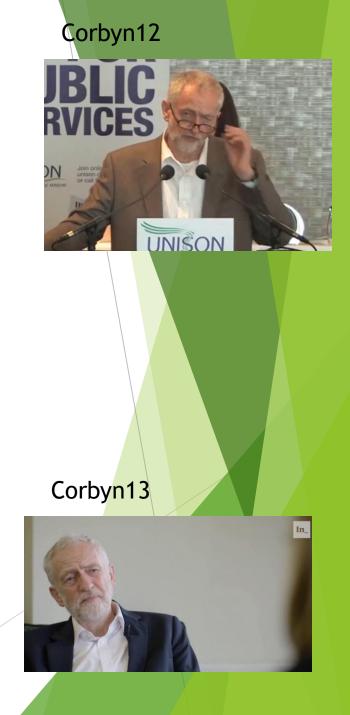
	Α	В	C	D	E	F	
1	Su	Video	ldx	Xloc	Yloc	Group	
2	1	Jeremy1	1	891	498	1	
3	1	Jeremy1	2	891	499	1	
4	1	Jeremy1	3	897	497	1	
5	1	Jeremy1	4	894	503	1	
6	1	Jeremy1	5	892	496	1	
7	1	Jeremy1	6	895	496	1	
8	1	Jeremy1	7	987	523	1	
9	1	Jeremy1	8	974	517	1	
10	1	Jeremy1	9	977	521	1	
11	1	Jeremy1	10	978	520	1	
12	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		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	В	С	D
1	ldx	Video	p_value	sign
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		Jeremy7	0.136373649379256	0
20	1	Jeremy8	0.511732738334228	0
21	1	Jeremy9	0.588069207426242	0



#### **Compare videos**





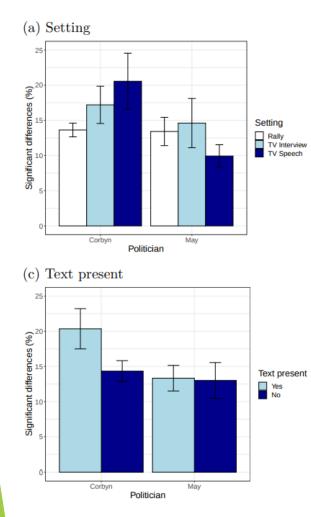
#### **Causes differences?**

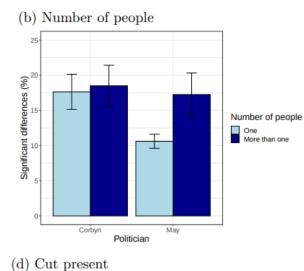
- Inspect sections of videos with 'significant' differences
- Inspect videos with 'significant' differences

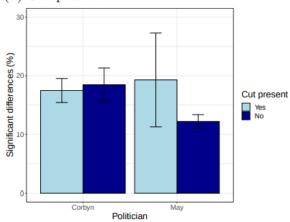




#### Video aspects









## Average viewing location

Labour



Labour

Non-Labour



Non-Labour



Labour



Non-Labour



Labour

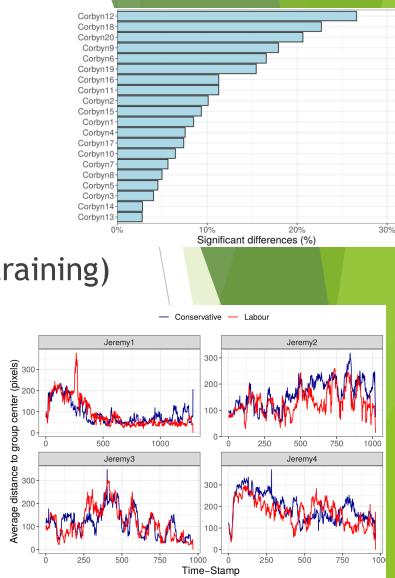


Non-Labour



# 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

	R	Load samples rom all participants and all videos andomly split samples in training and test
		participants (80-20%) Determine frames with 'significant' differences using the training participants Select frames with 'significant' difference and/or videos with >10% 'significant' differences selected
Repea		Compute group centers for each video frame with training participants
Repeat 18 times		Compute sample distance to group centers for each video and participant (training and test)
nie -		Compute average distance to group centers for each video and participant (training and test)
		Train models on training average distances, use cross-validation for training accuracy, compute accuracy for test set

#### Results

0%-

LR

Training Cross-Validation Test accuracy No selection Selection of videos 100%-75%-Classification performance (%) - エ **T** I 50%-T 25% 0% Selection of frames Selection of videos and frames 00%-75%-50%-25%

ŔF

Classifier

ĹŔ

DecTree

KNN

ŔF

DecTree

KŃN

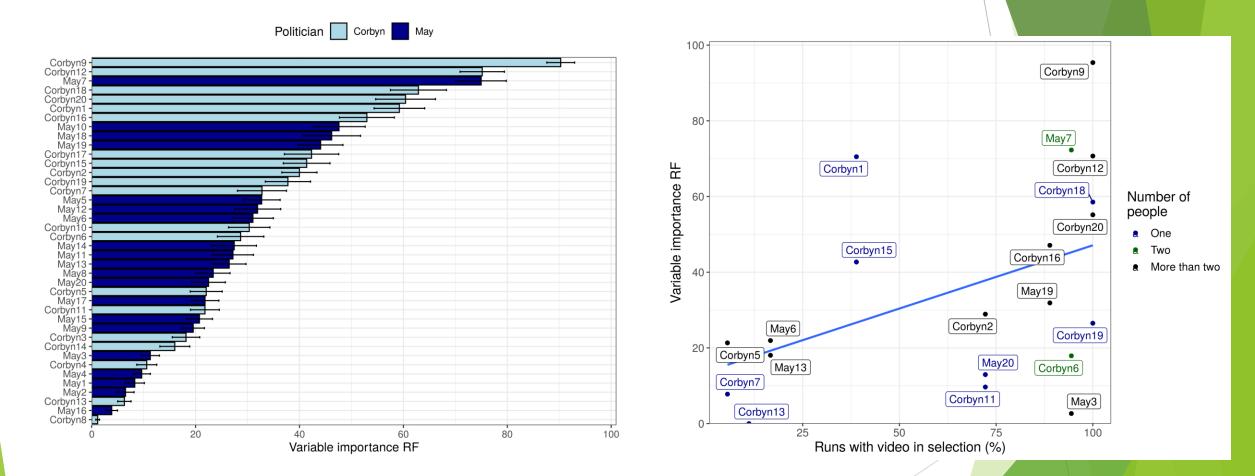
Labour

Non-Labour





#### Variable importance



#### Labour



Non-Labour



- 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

Summary

- Group membership seems related to fixating mouth (conservatives) or eyes (labour)
- Effects larger for left-wing politician

Labour



Non-Labour



#### **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

