Involuntary Eye-Movement Signatures Differ for Recognition of Oneself, Familiar and Unfamiliar Faces

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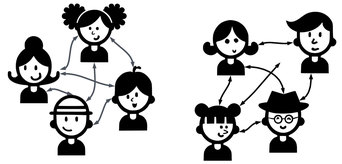
Preprint, data and code are on OSF!

Experiment

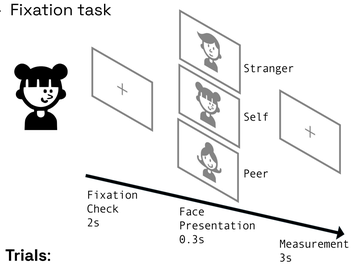
Background and Motivation

- **Pupil dilation and microsaccade rate (MSR)**, though primarily functionally driven, are modulated by cognition and emotion [4, 5].
- **Face recognition** is tightly coupled to visual, cognitive, and affective processing.
- In Oddball paradigms **infrequent** target stimuli cause **stronger pupil dilation** and **microsaccade inhibition** related to increased **attention.**
- Previous work shows that pupil dilation is modulated by face recognition, but evidence for MSR is inconclusive [1, 2, 3].
- Experiments typically use entrained faces or famous faces as familiar, not faces from participants real life.
- **Aim**:
  - Better understand the underlying processes of **face recognition**.
  - Research the potential use of oculomotor measures in revealing **hidden knowledge** or in **biometric identification** procedures.

Method



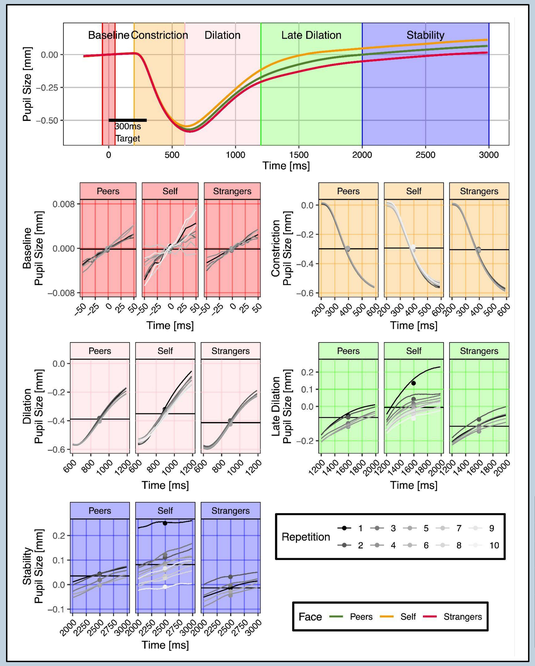
- **116 participants** from 2 schools
  -> Knew each other **within** their group but **not between groups**.
- A professional photographer took standardized pictures of all faces.
- Eye tracking using a Eyelink 1000, binocular, 500Hz
- Images were shown a 11.4° visual angle for 300ms.
- Fixation task



- **Trials**:
  - 10 x their own face (10 trials)
  - 5 x 3 selected peers (15 trials)
  - 5 x 3 selected strangers (15 trials)
  - 1 x 30 strangers (30 trials)
  - 1 x 30 peers (30 trials)
- DV: **Microsaccade** rate and **Pupil size**

Pupil Size

(simplified overview; see [4] for a review)



- We find significant differences comparing: **Self–Others** and **Peers–Strangers**
- Differences emerge primarily during **dilation**, mostly after 1.2 s
- Dilation decreases with **image repetition**
  - **Self:** strongest dilation for **first** presentation
  - **Stranger:** strongest dilation for **second** presentation
  - Linear Mixed Model (LMM):

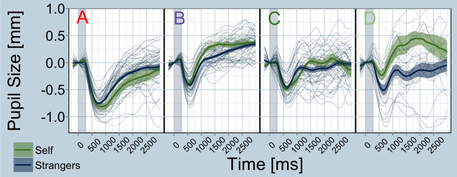
```
Pupil_Size ~ 1+ Face * Rep + Time + Trial
    + (1 + Face + Rep2 + Rep3 | Subj)
    + (1 + Face(Se – O) | Img)

Contrasts:
  - Face: (Self vs. Others), (Peers vs
    Strangers)
  - Repetition: sliding differences
    contrast
Covariates:
  - Time, Trial
Random Effects:
  - Subject, Image
```

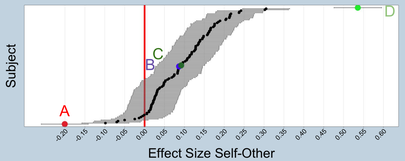
Phase	Se–O	P–St	1st - 2nd	2nd - 3rd	Se-O: 1st-2nd	P-St: 1st-2nd
Base.	-	-	-	-	-	-
Constr.	-	-	-	-	0.018 (t=-5.8)	-0.007 (t=-7.8)
Dilat.	0.052 (t=6.1)	0.009 (t=3.2)	-	-	-0.031 (t=-9.0)	-0.010 (t=-10.5)
Late D.	0.095 (t=8.5)	0.012 (t=3.4)	-0.028 (t=-3.0)	-0.024 (t=-2.3)	-0.092 (t=-25.6)	-0.028 (t=-26.8)
Stab.	0.072 (t=6.4)	0.013 (t=3.1)	-0.044 (t=-3.7)	-	-0.140 (t= -37.7)	-0.025 (t=-24.0)

Excerpt. For the full LMM output, see the paper

- Large **within-subject differences** between trials



- Large **between-subject differences:** some few even show a reliably inverse effect.

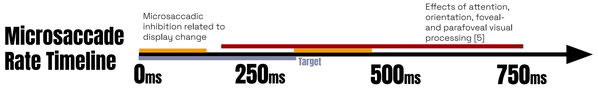


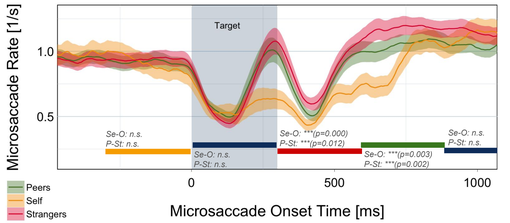
- In a post-experiment questionnaire, subjects rated all faces, with regard to **how well they knew each other.**

- Compared to acquaintances, **close friends** evoke responses **more similar to one's own face.**
- LMM confirms that the difference **Self-Close Friend** is significant **only in the window 1200-2000ms.**

Phase	Se–Cl	Se–Ac	Se–St	1st - 2nd	Se-Cl: 1st-2nd	Se-Ac: 1st-2nd	Se-St: 1st-2nd
Base.	-	-	-	-	-	-	-
Constr.	-	-	-0.008 (t=-2.2)	-0.022 (t=-2.5)	-0.039 (t=-8.6)	0.043 (t=11.86)	0.041 (t=11.6)
Dilat.	-	-0.049 (t=-6.0)	0.064 (t=-7.3)	-0.023 (t=-2.5)	-0.039 (t=-8.6)	0.043 (t=11.8)	0.042 (t=-11.6)
Late D.	-0.058 (t=-3.2)	-0.090 (t=8.4)	0.112 (t=10.0)	-0.090 (t=-9.1)	-	0.080 (t=23.3)	0.120 (t=32.4)
Stab.	-	-0.071 (t=-6.0)	-0.092 (t=8.0)	0.138 (t=-11.1)	0.062 (t=12.4)	0.124 (t=34.23)	-0.170 (t=43.2)

Microsaccades

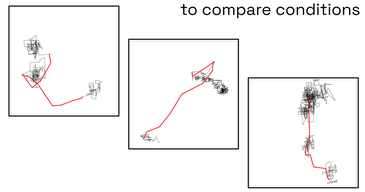




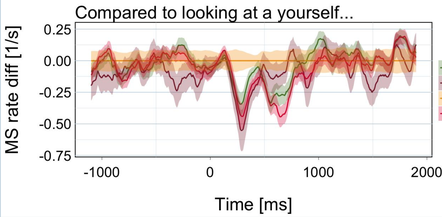
- We find significant differences comparing: **Self–Others** and **Peers–Strangers** in the time window of 300-600ms and 600-900ms.
- Differences emerge around 125 ms after target onset.
- Used **Poisson Rate test** to compare conditions

- We added to the LMM a factor for the presence of microsaccades in the most diagnostic window (300-600ms), i.e.,

```
Pupil_Size ~ 1 + MS_in_window * Face
    + (1 | Subj)
Contrasts:
  - Face: (Self vs. Others), (Peers vs
    Strangers)
  - MS_in_window: (MS vs no MS)
```



- **Presence/Absence** of Microsaccades shows an **effect on pupil size** only weakly, and only in the time windows 200-600ms and 600-1200



- Including the **closeness rating** shows that the **Close Friends** condition **behaves more like Aquaintances and Strangers** in MSR.
- MSR delays are much shorter than pupil size: **early reactions modulated only by own face** indicates that self-recognition is faster than other-recognition

Discussion

- **Self**-recognition, recognition of **familiar** faces, and **unfamiliar** faces cause different in MSR and Pupil signatures.
- The effect diminishes with image **repetition**, suggesting influences of **surprise** and **attention**, more than **recognition**.
- Self-recognition and recognition of close friends not easily distinguished in the pupil response.
- Potential applicability in **concealed information testing**.

References

[1] Chen, I. Y., Büchel, P., Karabay, A., van der Mijn, R., Mathot, S., & Akyurek, E. G. (2023). Concealed information detection in rapid serial visual presentation with oculomotor measures. *PsyArXiv*.
[2] Rosenzweig, G., & Bonneh, Y. S. (2019). Familiarity revealed by involuntary eye movements on the fringe of awareness. *Scientific Reports*, 9(1).
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[4] Mathôt, S. (2018). Pupillometry: Psychology, physiology, and function. *Journal of Cognition*, 1(1), 16.
[5] Engbert, R., & Kliegl, R. (2003). Microsaccades uncover the orientation of covert attention. *Vision Research*, 43(9),1035–1045.