N170 is Sensitive to Several Factors Important for Differentiating Individual Faces

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Background

The N170 ERP component responds differently to faces compared to other objects,[1] as shown in cross-category comparisons (i.e., face vs. non-face). Less is known about whether the N170 distinguishes individual faces, for which we know from behavioural data the eyes and facial layout are important.
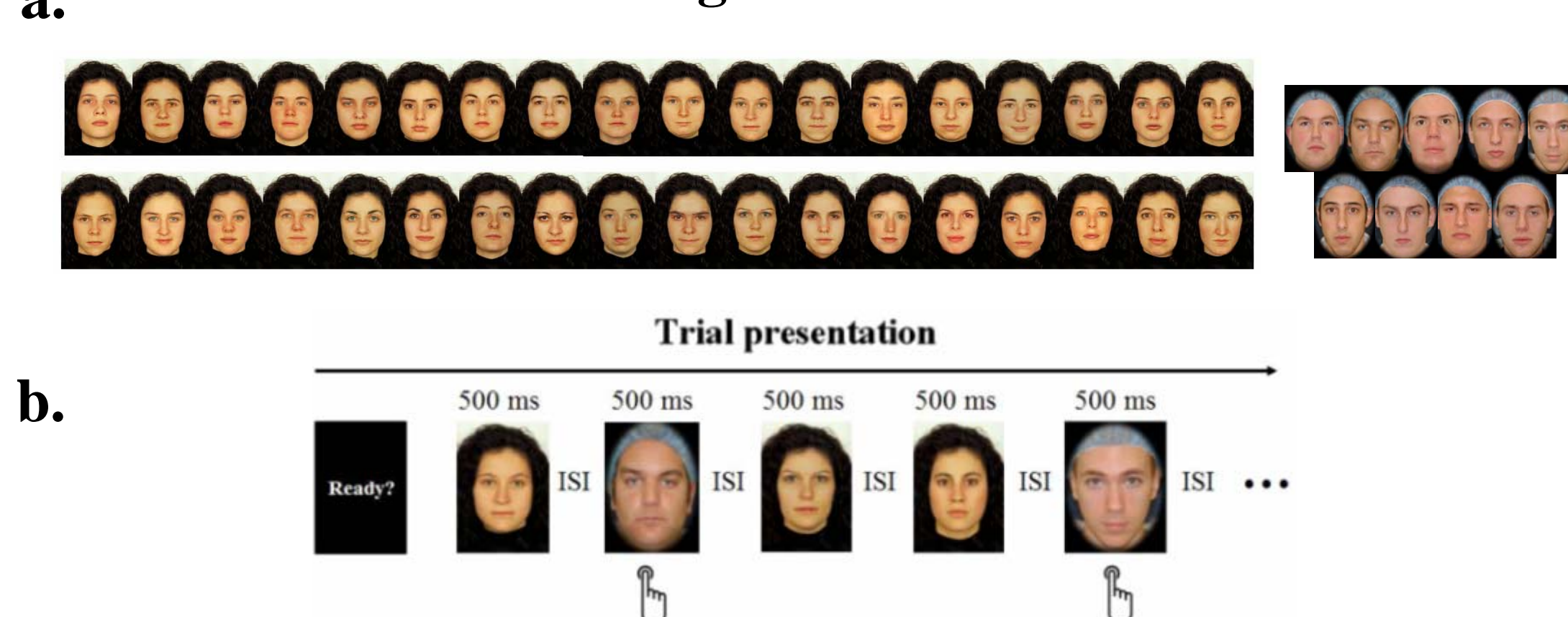
Current study: we investigated whether and how the face-sensitive N170 component would correlate with different facial characteristics of the eye region and facial layout from individual faces.

Method

Participants: 14 female adults (Mean age = 20.3 y)

Stimuli and Task: 36 colored Caucasian female faces from a previous study[2] and 9 colored Caucasian male faces (Fig. 1a). The female faces were cropped with the same hair style, and non-facial cues (e.g., mole) were removed using Photoshop CS 8.0©. In the previous study, a 4-dimensional "face-space" was constructed for the female face stimuli based on similarity ratings in a multi-dimensional scaling (MDS). Each dimension represents a factor that was used by participants to perceive similarities among faces.

Gender Decision Task: 4 blocks of 180 trials were presented in the current study. On each trial, participants would see either a female or a male face, and pressed a button for male faces (Fig. 1b). Faces were randomly presented 4 times within one block. Only ERPs to the female faces were analyzed.
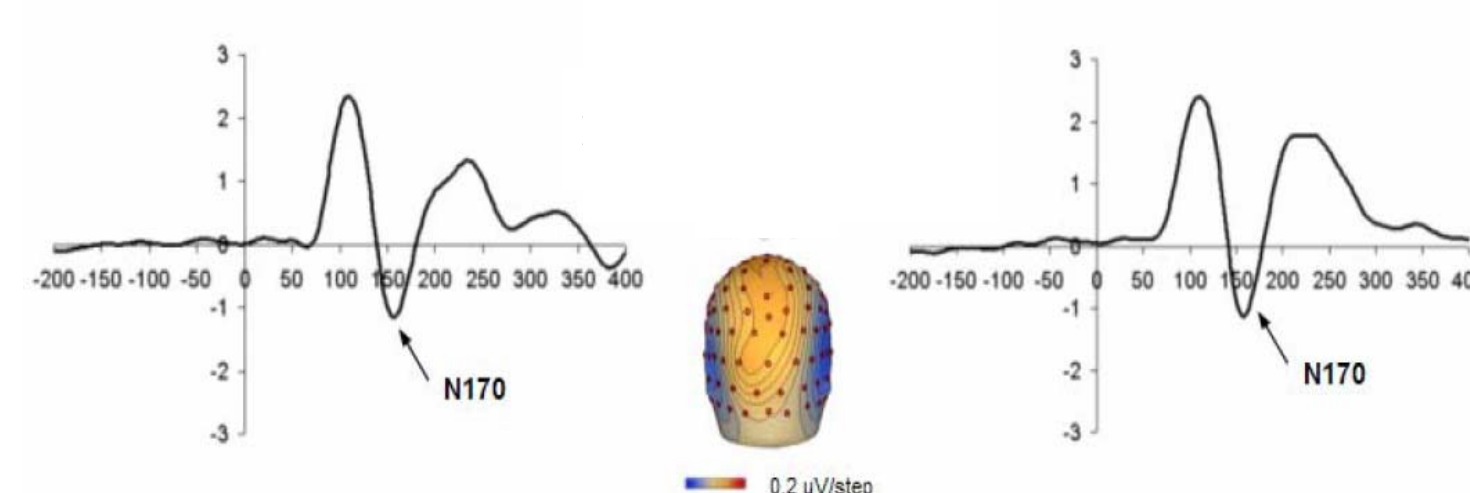

Figure 1

a.

b.

Trial presentation

500 ms 500 ms 500 ms 500 ms 500 ms

Electrophysiological Recordings:
- 128-Channel EGI System
- sampling: 500 Hz; filtered offline 1 to 30 Hz; Imped < 50 kΩ
- Epoch = 200 ms prestimulus, 800 poststimulus
- N170, measured as the maximum amplitude over left and right posterior occipital-temporal sites (P7/8, P9/10, PO7/8, PO9/10) between 130-190 ms post-stimulus onset (Fig. 2)
- N170 for each face stimulus was produced by averaging individual N170s to the face stimulus across 14 participants

Figure 2

Method

Measurements of face stimuli (Fig. 3)
- eye color: R-G-B color triplets
- eye-width: distance between two corners of an eye
- eye-height: distance between upper and lower eyelid
- top-of-face: distance from the top of the forehead to the mid-point between eyebrows
- bottom-of-face: distance from mid-point between eyebrows to the tip of the chin
- face-width: distance between cheekbones
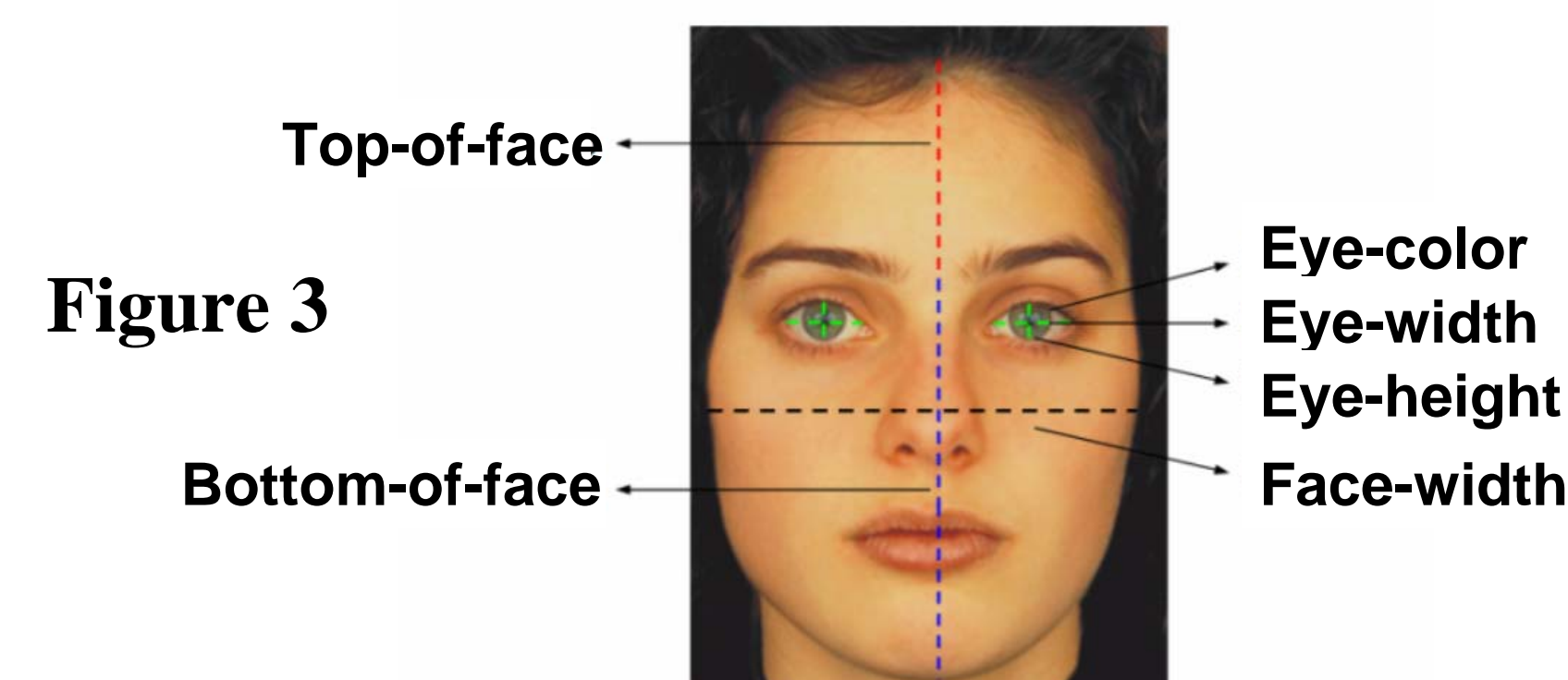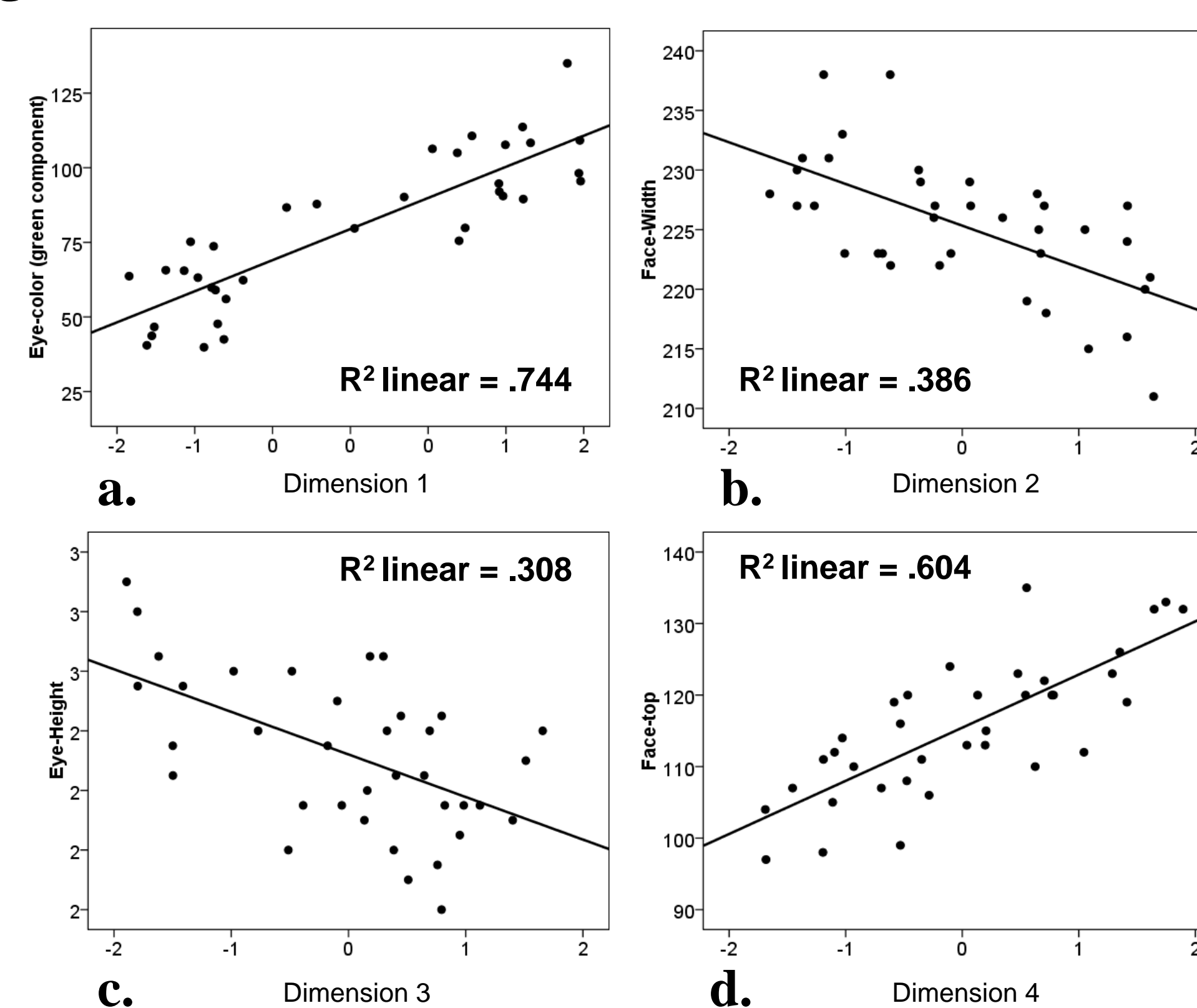- all measurements were done using Photoshop CS 8.0 ©

Figure 3

Top-of-face

Bottom-of-face

Eye-color
Eye-width
Eye-height
Face-width

Results

Face-space dimensions and face characteristics:

❖ Dimension-1 correlated with eye-color (green color component), $p < .001$ (Fig. 4a)
❖ Dimension-2 correlated with face-width, $p < .001$ (Fig. 4b) and face-bottom, $p = .021$ (not shown),
❖ Dimension-3 correlated with eye-height, $p < .001$ (Fig. 4c)
❖ Dimension-4 correlated with top-of-face, $p < .001$ (Fig. 4d)

Figure 4

a. R^2 linear = .744   Dimension 1
b. R^2 linear = .386   Dimension 2
c. R^2 linear = .308   Dimension 3
d. R^2 linear = .604   Dimension 4

ERP Results

❖ **Right N170**
  ➢ None of the 4 dimensions correlated with the right N170.

  ➢ **N170 and facial characteristics:**
    ▪ Sensitive to eye color (Dimension-1), indicated by green*red interaction, $p = .001$ (Fig. 5a)
    ▪ A curvilinear relationship with face-width (Dimension-2), $p = .01$ (Fig. 5b)
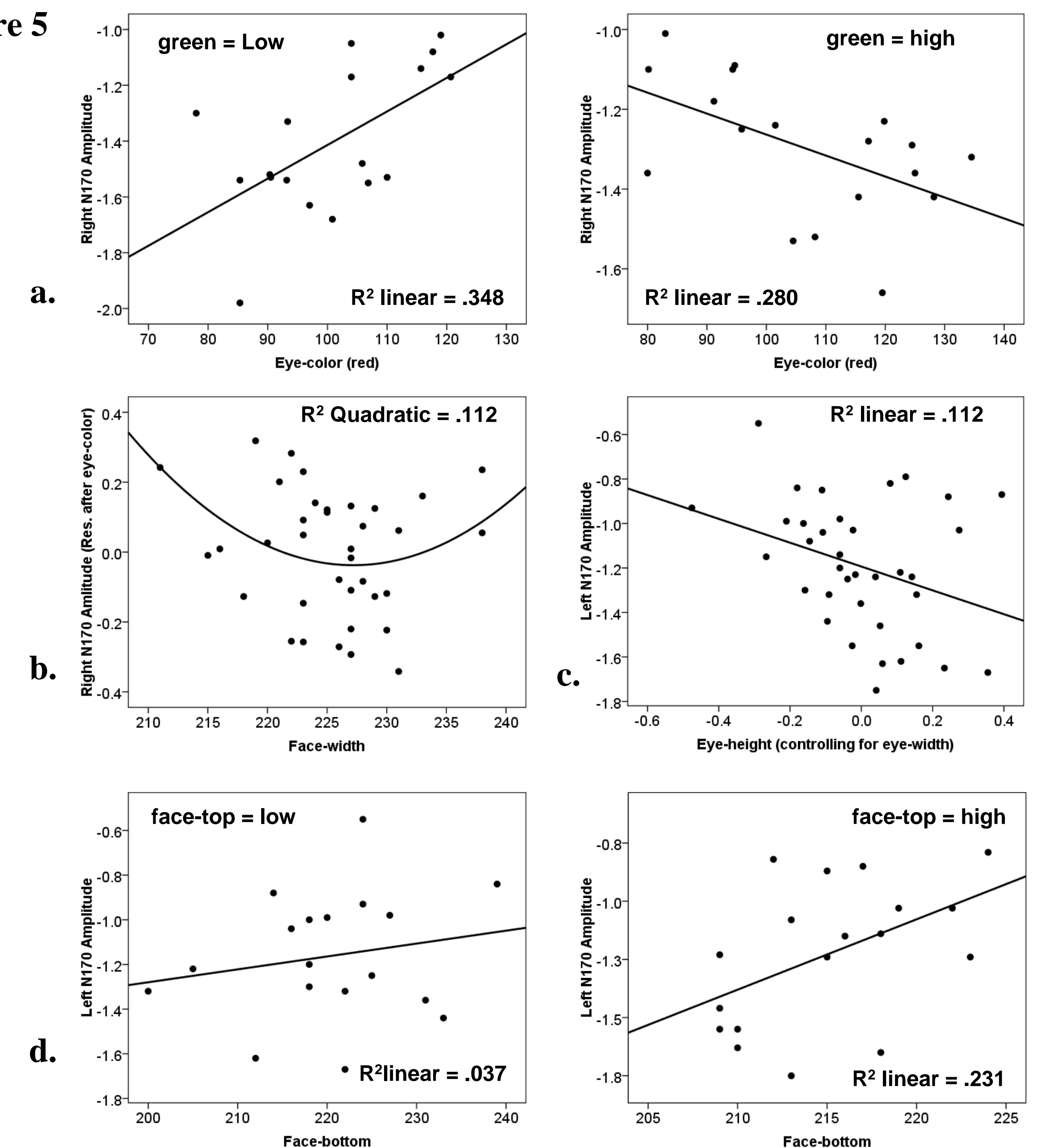   ▪ No relation with other measurements.

❖ **Left N170**
  ➢ None of the 4 dimensions correlated with the left N170.

  ➢ **N170 and facial characteristics:**
    ▪ Relates to eye-height (Dimension-3), $p = .049$, after controlling for eye-width (Fig. 5c)
    ▪ Relates to the top-of-face (Dimension-4), when bottom-of-face was high, $p = .020$ for top-of-face*bottom-of-face interaction (Fig. 5d)
    ▪ No relation with other measurements.

Figure 5

a. green = Low R^2 linear = .348   Eye-color (red)
   green = high R^2 linear = .280   Eye-color (red)
b. R^2 Quadratic = .112   Face-width
c. R^2 linear = .112   Eye-height (controlling for eye-width)
d. face-top = low R^2 linear = .037   Face-bottom
   face-top = high R^2 linear = .231   Face-bottom

Conclusions

1) From the face-space MDS results, we found that face-space dimensions correlated with facial features (e.g., eye-colour) and configurations (e.g., face-width).
2) N170 responses related additively to these facial characteristics, suggesting multiple contributions to the N170 amplitude.
3) The separate effects on the left and right N170 suggested the two hemispheres might use different face-processing mechanisms, depending on the complexity of analyses.
4) Since the ERPs are face-based averaged over the 14 participants, future research on face perception is needed to examine individual differences in these effects and their developmental trajectories.

References

(1) Bentin, S., Allison, T., Puce, A., Perez, E., & McCarthy, G. (1996). Electrophysiological studies of face perception in humans. *Journal of Cognitive Neuroscience, 8*(6), 551-565.
(2) Nishimura, M., Maurer, D., & Gao, X. (2009). Exploring children's face-space: A multidimensional scaling analysis of the mental representation of facial identity. *Journal of Experimental Child Psychology, 103*, 355-375.