Perceptual Integration of Simultaneous Facial Parts Does Not Predict Individual Differences in Face Recognition

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Context

- Classical theories of face perception propose that the ability to identify a face is not simply explained by an analysis of their constituent parts but rather by a holistic coding of the relationships between these parts[1].
- Using a method that explicitly measures perceptual integration efficiency for multiple facial features, it was shown that face identification is no better than what is predicted by efficiency for isolated parts[2]. Interestingly, face inversion still significantly decreased perceptual integration, which may suggest that expertise for upright faces comes from the ability to process multiple parts at once.
- The purpose of the present study was to test whether individual differences in face recognition is better explained by integrative processing, or simply by feature processing efficiency.

Method

Sixty-four (64) participants (35 women, M_{age}=22) were tested.

Perceptual integration task

- Participants were asked to memorize six (6) identities.
- Five (5) experimental conditions (*see Figure 1*).
- The Gold et al. (2012) paradigm[2] requires measuring the level of visual contrast needed to achieve a pre-specified performance (e.g. 75%) for each condition.

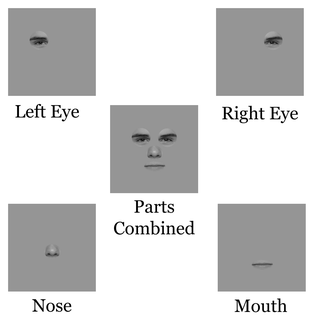

Figure 1 – Five experimental conditions for one of the six learned identities.

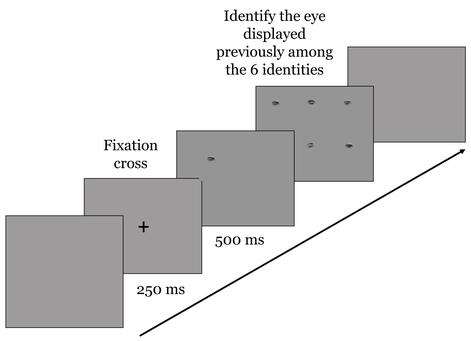

Figure 2 – Sequence of a trial of the integration task.

Face and object recognition tasks

- Cambridge Face Memory Test (CFMT)[3]
- Cambridge Face Perception Test (CFPT)[4]
- Glasgow Face Matching Test 2 (GFMT2)[5]
- Vanderbilt Expertise Test (8 categories of objects ; VET)[6]

Analysis and Results

1) An integration index (Φ) is calculated for each participant (*see Figure 4*) :

$$\Phi = \frac{S^2\ parts\ combined}{S^2\ left\ eye + S^2\ right\ eye + S^2\ nose + S^2\ mouth}$$

Figure 3 – Formula for the integration index. S is the contrast sensitivity, which is the reciprocal of the contrast level needed to achieve 75% performance (S = 1/contrast level).

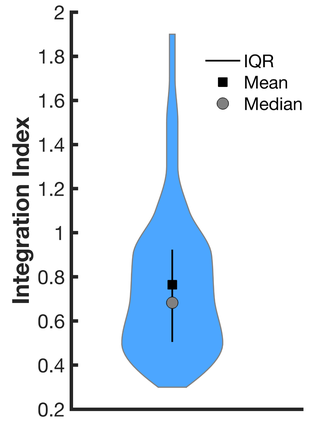

Figure 4 – Participant's integration index distribution (M_{Φ} = 0.76).

2) Three principal component analyses were performed:
   - **Face processing** abilities (FPA ; CFMT, CFPT, GFMT2).
   - **Isolated feature processing** efficiency (IFPE)
     (sensitivity thresholds : $M_{righteye}$ = 0.005, $M_{lefteye}$ = 0.007, M_{nose} = 0.035, M_{mouth} = 0.031).
   - **Object processing** abilities (OPA ; VET).

3) A hierarchical multiple linear regression analysis was conducted.
   - IFPE yielded a significant model, $F(1, 62) = 36.01$, $\boldsymbol{p < 0.001}$, $R^2 = 0.36$ ($\boldsymbol{\beta = -0.61}$).
   - The addition of OPA resulted in a significant improvement of the model ($F(1, 61) = 5.77$, $\boldsymbol{p = 0.02}$, $\Delta R^2 = 0.05$; $\boldsymbol{\beta = 0.28}$), while Φ did not, ΔR^2 = -0.003.
   - Finally, we calculated the Pearson and the Spearman correlations between FPA and efficiency with isolated features, as well as between FPA and integration index (*see Figures 5 and 6*).

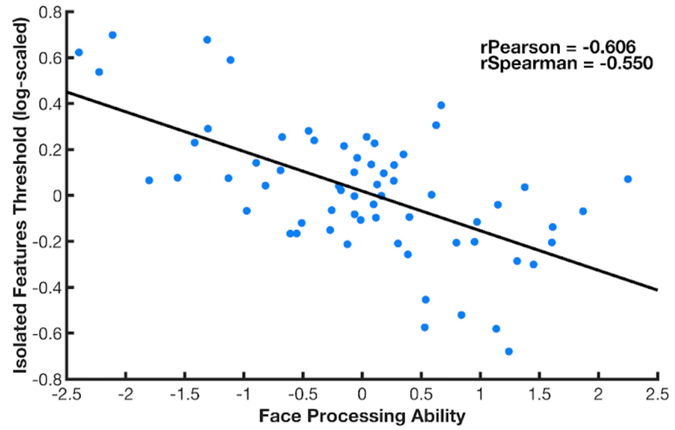

Figure 5 – Correlations between Isolated Features Processing Threshold (log-scaled) and Face Processing Ability (FPA).

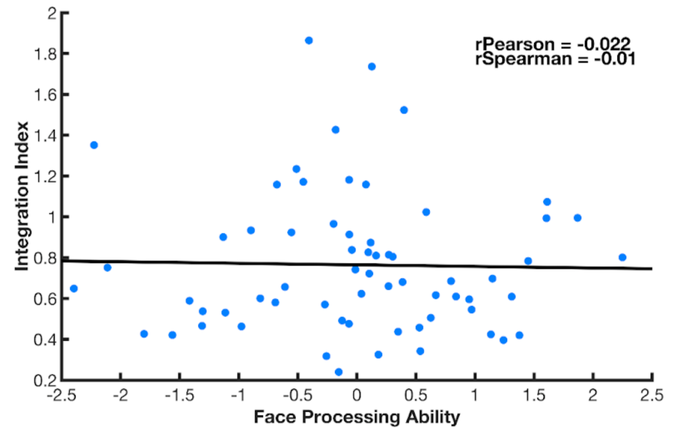

Figure 6 –Correlations between Integration Index and Face Processing Ability (FPA).

Discussion and Conclusion

The results unequivocally indicate that a substantial proportion of individual differences in FPA is explained by the ability to process face parts, as well as a small proportion explained by OPA. Importantly, perceptual integration was not statistically associated with FPA. Thus, it appears perceptual integration--and by extension, holistic processing--is in no meaningful way involved in accounting for individual differences in FPA.

References

(1) DeGutis, J., Wilmer, J., Mercado, R. J., & Cohan, S. (2013). Using regression to measure holistic face processing reveals a strong link with face recognition ability. *Cognition, 126*(1), 87-100. https://doi.org/10.1016/j.cognition.2012.09.004 **(2)** Gold, J. M., Mundy, P. J., & Tjan, B. S. (2012). The perception of a face is no more than the sum of its parts. *Psychological science, 23*(4), 427-434. https://doi.org/10.1177/0956797611427407 **(3)** Duchaine, B., & Nakayama, K. (2006). The Cambridge Face Memory Test: Results for neurologically intact individuals and an investigation of its validity using inverted face stimuli and prosopagnosic participants. *Neuropsychologia, 44*(4), 576-585. https://doi.org/10.1016/j.neuropsychologia.2005.07.001 **(4)** Duchaine, B., Germine, L., & Nakayama, K. (2007). Family resemblance: Ten family members with prosopagnosia and within-class object agnosia. *Cognitive neuropsychology, 24*(4), 419-430. https://doi.org/10.1080/02643290701380491 **(5)** White, D., Guilbert, D., Varela, V. P., Jenkins, R., & Burton, A. M. (2021). GFMT2: A psychometric measure of face matching ability. *Behavior Research Methods*, 1-9. https://doi.org/10.3758/s13428-021-01638-x **(6)** McGugin, R. W., Richler, J. J., Herzmann, G., Speegle, M., & Gauthier, I. (2012). The Vanderbilt Expertise Test reveals domain-general and domain-specific sex effects in object recognition. *Vision research, 69*, 10-22. https://doi.org/10.1016/j.visres.2012.07.014

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