Joint Sampling of the Full Spectrum of Spatial Frequencies and Orientations During Face Recognition

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Introduction

Face identification relies on a specific range of low-level visual information. Optimal information is located between 8 and 16 cycles per face[1] (cpf) for spatial frequencies (SF) in horizontal spatial orientations (SO)[2]. While both SFs' and SOs' contributions to efficient face perception have been studied extensively, they were almost always studied in isolation from one another. Previous work[3] has successfully combined both properties, albeit limiting the sampled range to only three SF bands (2.66, 10,66 and 42,66 cycles per face) and two SOs (horizontal and vertical), showing that horizontal SOs are more important for recognition, especially for both 10.66 cpf and 42.66 cpf SF bands.

The present study aims to help further research into combinations of SFs and SOs by presenting a novel method (SFO Bubbles) to sample the full spectrum. We also use this method to compare SF/SO use for recognition of White and Asian faces.

Methodology

- 28 Caucasian participants.
- 2 000 trials of a same/different face matching task, evenly split for White/Asian faces.
- 24 possible identities per face ethnicities; 12 male, 12 female.

SFs and SOs were sampled in the Fourier spectrum using a new method combining principles from *Bubbles*[4] with the configuration of the *Gabor Rosette Map*[5]. This method consists in placing symmetrical gaussian filters in Fourier space. Random filters were placed on one of 180 possible SOs (0-179°) between 1-128 cpi (distance from the center). Filters sampling higher SFs are larger to compensate for lower energy in each individual SF. This allows for random sampling of the full spectrum of SFs and SOs, while maintaining the global structure of face stimuli intact.

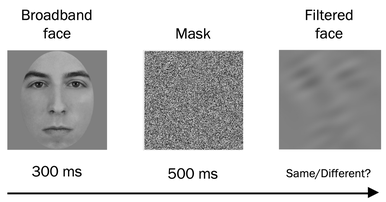

Figure 1. Experimental task diagram

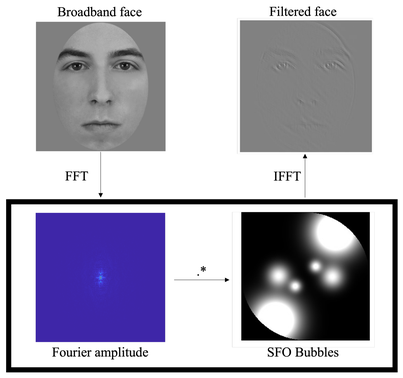

Figure 2. Image filtering process. The SFO Bubble is applied on the Fourier transform of the image.

Results

Final classification images for each participant were computed using a weighted sum of the presented filters. Succesful trials were given a positive weight, while failed trials were given a negative weight. T scores were then computed for each pixel. A pixel test[6] was performed on the Cis for each face ethnicity (T_{crit} = 7.66, $p < .001$). For both face ethnicities, mid-to-high spatial frequencies peaking at 12.66 cpf centered at around 2.5° were optimal for efficient face recognition. Using a paired T-test, we reveal no differences between face ethnicities (Max T = 3.12; Mean T = .81).

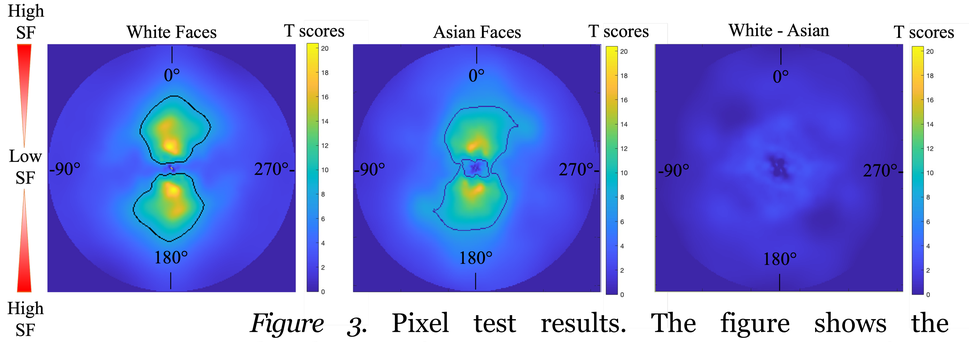

Figure 3. Pixel test results. The figure shows the distribution of T scores across Fourier space. Significant pixels are circled in black.

Conclusion

The present study shows a promising new method for sampling SFs and SOs simultaneously. The SFO Bubbles method could be used to explore individual differences in SFs and SOs use, while also revealing potential interactions. Our results are consistent with previous work, showing that horizontal information in mid-range SFs is important for face recognition. We aim to use the SFO Bubbles method to explore how culture may have an impact on SF and SO use in face recognition.

References

1) Näsänen, R. (1999). Spatial frequency bandwidth used in the recognition of facial images. Vision Research, 39(23), 3824–3833.
2) Duncan, J., Royer, J., Dugas, G., Blais, C., & Fiset, D. (2019). Revisiting the link between horizontal tuning and face processing ability with independent measures. Journal of Experimental Psychology: Human Perception and Performance, 45(11), 1429.
3) Goffaux, Valerie, van Zon, J., & Schiltz, C. (2011). The horizontal tuning of face perception relies on the processing of intermediate and high spatial frequencies. Journal of Vision, 11(10), 1–1.
4) Gosselin, F., & Schyns, P. G. (2001). Bubbles: A technique to reveal the use of information in recognition tasks. Vision Research, 41(17), 2261–2271.
5) Chen, C.-M., Lu, H. H.-S., & Han, K.-C. (2001). A textural approach based on Gabor functions for texture edge detection in ultrasound images. Ultrasound in Medicine & Biology, 27(4), 515–534.
6) Chauvin, A., Worsley, K. J., Schyns, P. G., Arguin, M., & Gosselin, F. (2005). Accurate statistical tests for smooth classification images. Journal of Vision, 5(9), 1–1.

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