Revealing Visual Information Use Through Random Sampling of Spatial Frequencies and Orientations

Francis Gingras[1 2], Jessica Limoges[1], Justin Duncan[3], Frédéric Gosselin[4], Daniel Fiset[1], Caroline Blais[1]

(1) Department of Psychology, Université du Québec en Outaouais
(2) Department of Psychology, Université du Québec à Montréal
(3) Department of Psychology, University of Fribourg
(4) Department of Psychology, University of Montreal

Introduction

Face identification relies on a specific range of low-level visual information. Recognition ability peaks in the range of 8 to 16 cycles per face[1] for spatial frequencies (SF), while horizontal spatial orientations (SO) carry critical information[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 (4, 16 and 64 cycles per image) and two SOs (horizontal and vertical), showing that horizontal SOs are more important for recognition, especially for both 16 cpi and 64 cpi SF bands.

The present study aims to improve our understanding of how the combination of SFs and SOs helps face identification. We do so by using random sampling of combinations of SFs and SOs based on the *Bubbles*[5] method.

Methodology

- 7 participants.
- 1 500 trials of a same/different face matching task.
- 24 possible identities; 12 male, 12 female.
- SFs and SOs were sampled using a combination of the *Spatial Frequency Bubbles*[4] and the *Spatial Orientation Bubbles*[5].

For analyses, a weighted sum of all filters shown to participants was computed using *Matlab* by converting accuracy vectors to *z*-scores. Stimuli that led to a successful trial were weighted positively, while those that led to unsuccessful trials were weighted negatively. This allowed the construction of a 2D classification image representing relevant information for face recognition in the Fourier domain.

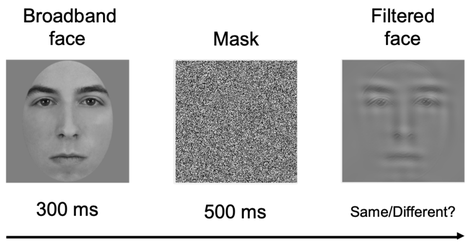

Figure 1. Experimental task diagram

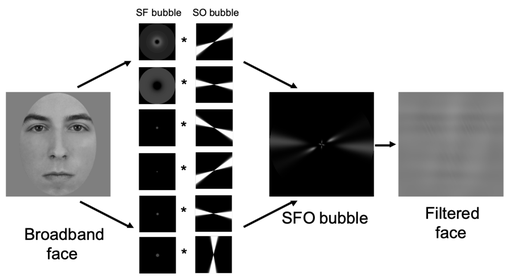

Figure 2. Image filtering process

Results

Results show that a combination of spatial frequencies peaking at 15 cycles per face (width of 2.3 octaves) at orientations centered at 1° (width of 15°) was the most used information to complete the task. This is consistent with prior results showing that horizontal information in the mid-to-high spatial frequencies is sufficient for face recognition.

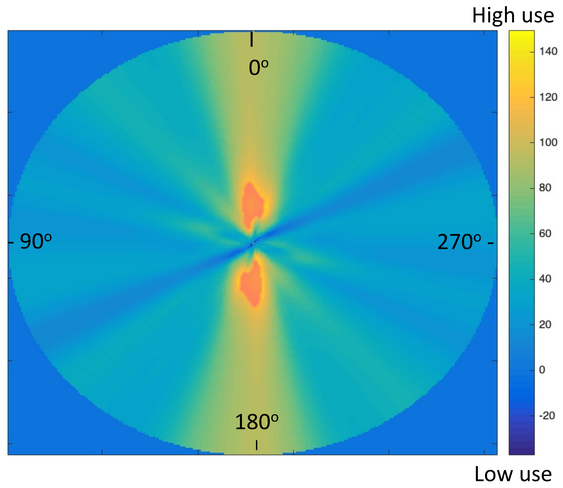

Figure 3. Summed classification image across all participants in the Fourier domain. Relevant angles are indicated on the edges of the image. Low SFs are located closer to the center, while high SFs are further away from the center. Top 1% of used information is highlighted in red. Yellow corresponds to higher information use, blue to lower information use.

Conclusion

The present study contributes to give a more complete picture of the SFs and SOs used in face recognition by accounting for every possible combination of the two types of visual information. This method allows for a higher resolution for both parameters, allowing finer comparisons to be made between tasks or groups. Our results are consistent with previous work, showing that horizontal information in middle range SFs is important for face recognition. Future work will aim to explore possible individual and cultural differences in SF and SO use during face recognition. A new method for sampling SFs and SOs simultaneously, based on Gabor Rosette maps, is also being developed.

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) Willenbockel, V., Fiset, D., Chauvin, A., Blais, C., Arguin, M., Tanaka, J. W., Bub, D. N., & Gosselin, F. (2010). Does face inversion change spatial frequency tuning? Journal of Experimental Psychology: Human Perception and Performance, 36(1), 122.
5) Duncan, J., Gosselin, F., Cobarro, C., Dugas, G., Blais, C., & Fiset, D. (2017). Orientations for the successful categorization of facial expressions and their link with facial features. Journal of Vision, 17(14), 7–7.

NSERC CRSNG
UQO
GNS SNG
LPVS-UQO
lpvs-uqo.ca