Right hemisphere horizontal tuning during face processing

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Context

- Lesion[1] and neuroimaging[2] studies suggest that face processing is largely undertaken by right hemisphere cerebral regions.
- Behaviorally, superiority of the left visual field (LVF), i.e., the finding that faces are processed with greater speed and accuracy, vs. the right hemifield[3], can be observed thanks to the separation of the visual fields along a vertical line that traverses the fovea[4], and decussation of the visual pathways.
- Possible explanations include global/local[5] and low/high spatial frequency[6] processing specialization in the right (RH)/left (LH) hemispheres, respectively. Given the growing interest for spatial orientations in various aspects of face processing (detection[7], identification[8], emotion recognition[9]), we used orientation bubbles[9] (**Figure 1**) to explore the processing of this facial information across the hemispheres.

Methods

- 37 participants, right-handedness verified with Edinburgh Inventory[10], ≥ +60 (7 excluded; final sample size N = 30),
- 18-33 years old (M = 20.4, SD = 2.9).

Learning phase

- Familiarization (max. 20 minutes);
- Blocks of 100 trials of a 10 AFC face identification task, whereby stimulus durations was reduced from 1,000ms to 500ms, to 250ms, to 120ms, and to 60ms, each time a block was completed with ≥ 90% correct response.

Experiment 1—Baseline orientation profiles

- 5 blocks X 100 trials of a 10 AFC face identification task;
- Stimulus duration was 60ms;
- Performance was maintained near 55% by adjusting the number of bubbles (i.e., quantity of signal) using QUEST[11].

Experiment 2—Hemispheric orientation profiles

- 15 blocks X 40 trials (tot. 600, i.e., 300 trials/hemisphere) of a same/different task[6] (see, for procedure, **Figure 2**);
- An orientation-filtered probe was presented unilaterally for 60ms (non-probe half was an average face distractor);
- Performance maintained near 75% across both hemispheres by adjusting the number of bubbles filtering the probe with QUEST;
- Eye-tracking was used to measure central fixation compliance (M = 97.7% of trials, SD = 3.1%).

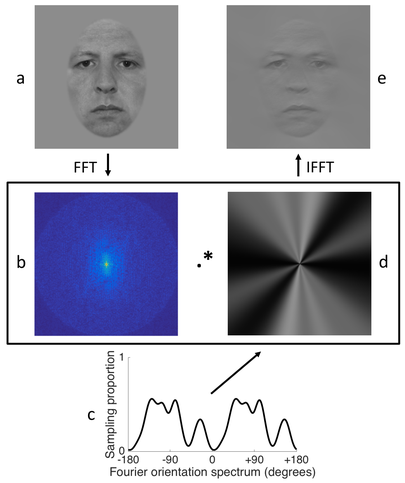

Figure 1. Orientation bubbles filtering procedure. The base image (a) orientation content is revealed by applying a Fast Fourier Transform (FFT) and shifting the resulting quadrants (b). An *orientation sampling vector* (c) comprising (here, 33) pairs of symmetrical Von Mises distributions is then converted to an *orientation sampling matrix* (d). The orientation matrix is applied to the image orientation content, and the filtered stimulus is reconstructed by inverse-FFT.

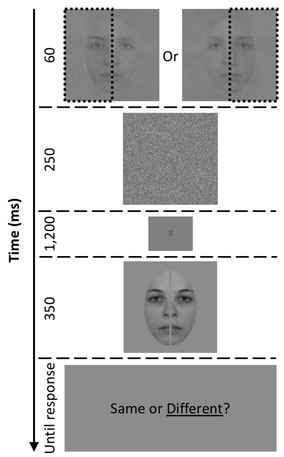

Figure 2. Experiment 2 trial. An orientation-filtered probe is presented (60ms) unilaterally (non-probe half is an average face distractor), followed by a noise mask (250ms), ISI (1,200ms), and broadband target (350ms). Subjects must tell if the probe and target are the same person or not.

Analyses and Results

- Orientation bubbles data were analyzed with a classification image analysis[12, 13]: We calculated a weighted sum of orientation filters, allocating positive/negative weights (*z*-scored accuracies) to filters that led to correct/incorrect responses, respectively;
- Classification vectors were standardized using the mean and standard deviation of the null hypothesis[9], summed to create a single group vector (divided by $\sqrt{N}$), and submitted to a pixel test[14], *Zcrit*= 2.1, $p < .05$ (two-tailed), corrected for multiple observations.

Experiment 1

- 42.3 bubbles (SD = 24.1) were needed.
- Information around the horizontal axis [−92° to −56°] positively correlates with task accuracy (**Figure 3**), *Zmax* = 3.38, $p < 0.005$.

Experiment 2

- 44.4 bubbles (SD = 15) needed to maintain 81% (SD = 5.6%) correct responses in the LVF/RH and 73.5% (SD = 5.1%) in the RVF/LH, and the difference between hemifields was significant, $t(29) = 5.13$, $p < 0.001$, $d = 0.94$;
- Response times were also faster in the LVF (M = 756ms, SD= 179), vs. RVF (M = 772ms, SD = 176), $t(29) = 2.33$, $p < 0.05$, $d = 0.43$;
- For the LVF/RH, information around the horizontal axis [−93° to −54°] positively correlates with task accuracy (**Figure 4**, black), *Zmax* = 3.45, $p < 0.001$.
- For the RVF/LH however, horizontal information marginally negatively correlates with task accuracy (**Figure 4**, dark grey), *Zmax* = −1.92, $p < 0.1$.
- A direct comparison of the two profiles by subtraction (**Figure 4**, light grey) reveals significant differences around the horizontal ([−97° to −64°]; *Zmax* = 3.76, $p < 0.001$) and vertical ([−180° to −142°]; *Zmin* = −2.85, $p < 0.01$) axes.

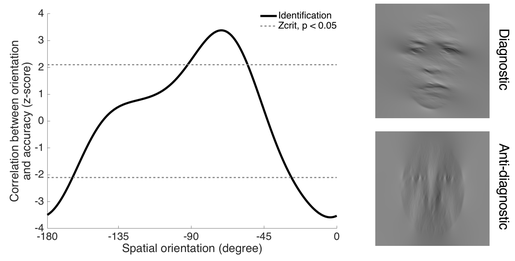

Figure 3. Experiment 1 results. (Left) Group classification vector illustrates the correlation (*z*-score) between orientation and task accuracy for face identification. Dotted lines plot the two-tailed significance threshold, *Zcrit* = 2.1, $p < 0.05$. (Right) Images filtered with diagnostic (top) and anti-diagnostic (bottom) orientations.

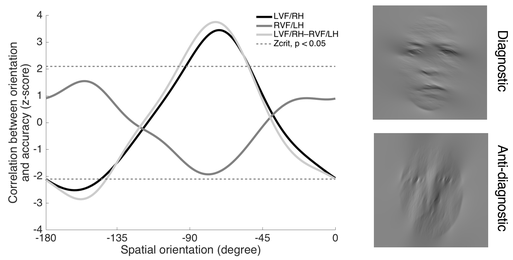

Figure 4. Experiment 2 results. (Left) Group classification vectors illustrating the correlation (*z*-score) between orientation and task accuracy in the left hemifield (black), and the right hemifield (dark gray); and the difference between both hemifields (light gray). Dotted lines plot the two-tailed significance threshold, *Zcrit* = 2.1, $p < 0.05$. (Right) Images filtered with diagnostic (top) and anti-diagnostic (bottom) orientations.

Discussion

- The group orientation profile extracted from Experiment 1 confirms that horizontal information is diagnostic of face identification, and accuracy and speed data from Experiment 2 confirm that the LVF superiority in face processing was successfully replicated in this protocol;
- Orientation profiles extracted from Experiment 2 show that the LVF/RH, but not the RVF/LH, relies on diagnostic horizontal face structure—in fact, horizontal information marginally increased error rates in the RVF/LH;
- Thus, superiority of the LVF might emerge as a result of different orientation tuning across the hemispheres.

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