N170 sensitivity to the horizontal information of facial expressions

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Context

- There is a growing interest in the role that horizontal information plays in various aspects of face processing such as detection[1], identification[2], the inversion effect[3], and emotion recognition[4].
- The face-sensitive N170 event-related potential[5], has been linked with horizontal facial information: Indeed, the N170 face inversion effect—that is, increased amplitude for inverted faces, compared with upright faces—was shown to be supported by horizontal facial structure[6].
- Additionally, the N170 has been linked with processing of the eyes[7] and processing of the diagnostic facial features of emotions[8].
- Here, we used orientation bubbles[4] to study the time-course of the association between electrophysiological (EEG) amplitude in the N170 window and diagnostic horizontal information, along with the rest of the spectrum, in a facial expression categorization task.

Methods

- 5 participants, right-handed.
- Task: Categorization of the 6 basic facial expressions[9] + neutrality.
- A total of 35,000 trials were completed (1,000 trials per expression condition per participant).
- Face stimuli (150 ms presentation) were randomly filtered (**Figure 1**) with orientation bubbles[4].
- Performance was maintained at 57.14% by adjusting image RMS contrast with QUEST[10].
- EEG activity was measured with 64 electrodes and sampled at 256 Hz.

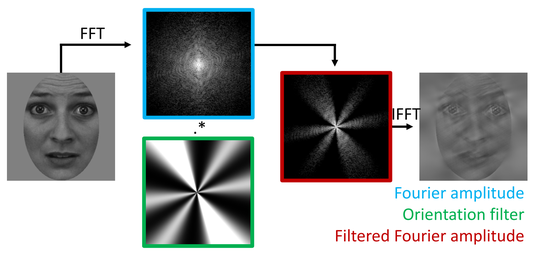

Figure 1. Orientation bubbles filtering procedure. For each face stimulus, the original image Fourier amplitude (blue outline), obtained with a Fast Fourier Transform (FFT), is dot-multiplied by an orientation filter (green outline) consisting in 10 random-mean Von Mises distributions (i.e., orientation bubbles). The stimulus is then reconstructed by inverse-FFT of the filtered Fourier amplitude (red outline).

Analyses and Results

Behavioral data: Facial emotion categorization

- Orientation bubbles data were analyzed with a classification image analysis[11, 12], similar to a multiple linear regression: 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 z-scored using the mean and standard deviation of the null hypothesis[4], and submitted to a pixel test[13], which corrects for multiple observations but also accounts for the spatial correlation inherent to bubbles, $Zcrit = 2.49$, $p < .05$ (two-tailed).
- Information around the horizontal (-90 deg) axis positively correlates with accurate emotion recognition for all expressions, except surprise (**Figure 2**), replicating previous findings[4].

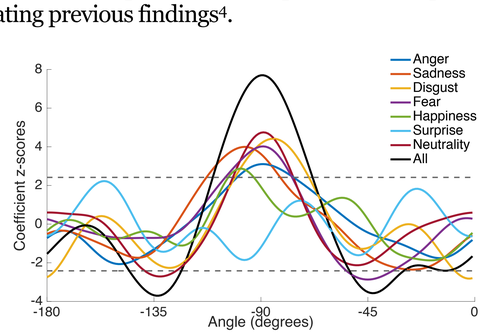

Figure 2. *Z*-scored classification vectors for emotion categorization task. Dotted grey lines represent the statistical threshold, $Zcrit = 2.49$, $p < .05$.

EEG data

- EEG data was first referenced to mastoid electrodes and bandpass filtered (1-30 Hz); it was then epoched between -300 and +700 ms, relative to stimulus onset, and eye-movements were removed using ICA. Finally, single-trial spherical spline current source density was computed using the CSD toolbox[14, 15].
- Data from P8—the electrode with the largest N170 component—was submitted to a classification image analysis[7, 11, 12]: At each sampled point in time, we calculated a weighted sum of orientation bubbles, allocating positive/negative weights (amplitudes, z-scored across trials) to orientation filters that led to higher/lower amplitudes, respectively.
- Before being combined, individual classification images were *z*-scored, using the 300 ms window preceding stimulus onset—i.e., the signal-less region of the classification image[13]—and indexed to -74.2 to +78, ms relative to the N170 peak, to alleviate individual differences in N170 peak latency.

EEG data (cont.)

- *Z*-scored classification images were finally submitted to a pixel test[13], $Zcrit = 3.89$, $p < .05$ (two-tailed).
- Horizontal (-90 deg) information negatively correlates with P8 amplitude (**Figure 3**; top)—i.e., leads to increased negativity—in the 50.8 ms preceding and including the N170 peak (**Figure 3**; bottom); conversely, oblique (-135 and -45 deg) information leads to decreased negativity during this period.
- The maximum correlation between P8 amplitude and horizontal information ($Z = -10.88$) is observed 27.3 ms prior to the N170 peak, and continuously decreases thereafter.
- Moment-to-moment P8 amplitude (**Figure 4**; blue line), on its own, appears to be a poor predictor of horizontal information processing (**Figure 4**; red line), $r_{Spearman} = .24$.
- In exploring alternative predictors, we verified if moment-to-moment changes in P8 amplitude (**Figure 4**; green line) might be better suited and found that indeed, such is the case, $r_{Spearman} = .99$.

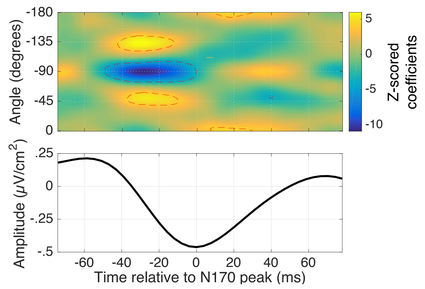

Figure 3. (Top) *Z*-scored classification image, illustrates the time-course of the association between P8 amplitude and the orientation spectrum. Dotted red lines represent the two-tailed statistical threshold, $Zcrit = 3.89$, $p < .05$. (Bottom) P8 amplitude (μV/cm²) is plotted from -74 to +78 ms, relative to the N170 peak (0 ms).

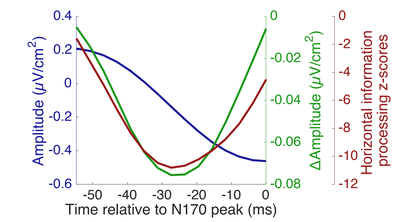

Figure 4. Plot of (blue line) P8 amplitude, (green line) changes in P8 amplitude, measured as $\Delta Amplitude_t = Amplitude_t - Amplitude_{t-1}$, and (red line) *z*-scored coefficients of the association between P8 amplitude and horizontal information. The time-course of this association is not well predicted by moment-to-moment P8 amplitude, $r_{Spearman} = .24$; but is instead almost perfectly predicted by moment-to-moment changes in amplitude, $r_{Spearman} = .99$.

Discussion

- In line with previous results[8], we observed a strong modulation of P8 amplitude by diagnostic—here, horizontal—facial information in the ≈50 ms window leading to, and including, the N170 peak.
- In a previous paper[4], we have shown that horizontal tuning is best predicted by processing of the eye region in a facial expression categorization task; thus, these results might reflect enhanced processing of the eyes[7] when horizontal facial information is available.
- Finally, our results suggest that moment-to-moment amplitude fluctuations—rather than raw amplitudes—best reflect the engagement of face processing mechanisms indexed by the N170.

References

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