Wavelet-based image decomposition affects SSVEP signal amplitude for face identification

Jérémy Lamontagne, Laurianne Côté, Justin Duncan, Caroline Blais, Émilie Désaulniers & Daniel Fiset
Département de Psychoéducation et de psychologie, Université du Québec en Outaouais

Introduction

Recent parametric studies of the identity processing during the N170[1] and N250[2] time windows have shown that their amplitude varies on a continuum and is proportional to the amount of information available for their respective cognitive processes. This study aimed at replicating the parametric response amplitude to stimuli found in event-related potentials (ERP) studies using SSVEP by manipulating the amount of information available using wavelet randomization and stimulation frequency.

Method

This study used an oddball SSVEP paradigm, with one stimulation cycle showing five consecutive images of the same identity, followed by an oddball face (i.e., different identity; see Figure 1). Each of the 45 blocks consisted of 53 such cycles. This SSVEP protocol was completed by 20 participants. We used a two-factor within subject design, with five levels of wavelet noise (0-20% with 5% increments; see Figure 2) and three simulation frequencies (4, 5 and 6Hz). EEG data were collected throughout the experiment with a g.tec 64-electrode cap using the 10-20 international system.

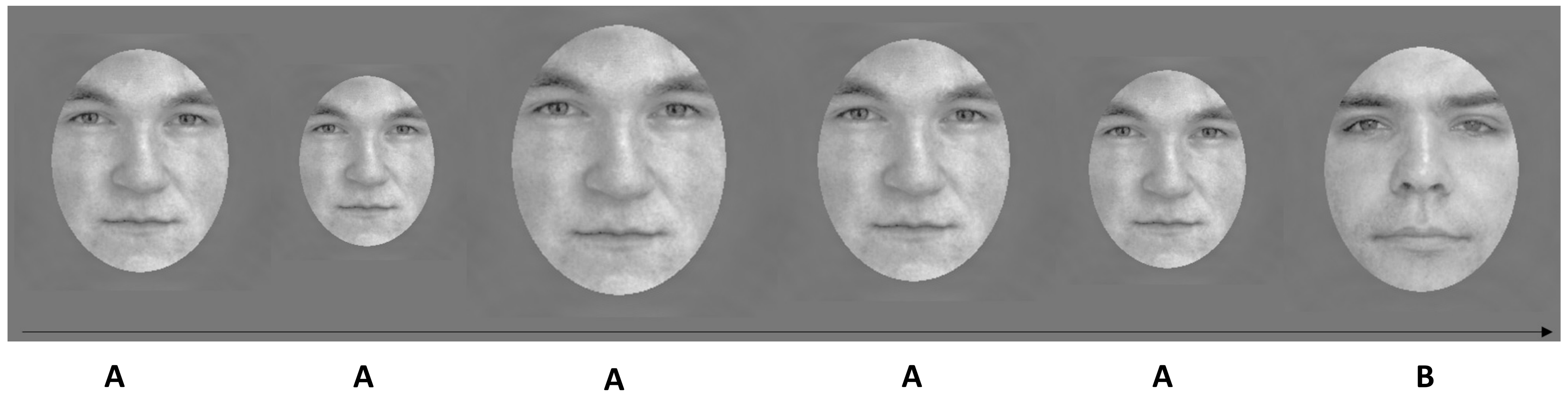

Figure 1. Example of a stimulation cycle, repeated 53 times per trial. Face size varied randomly from 90% to 110% original image size.

Figure 2. Wavelet noise from 0% (leftmost) to 20% (rightmost) in 5% increments.

Analyses

EEG data were transformed into the frequency domain using FFT to analyze brain synchronization with the oddball (see Figure 3). Baseline-corrected values were added across the oddball frequency and its first 5 harmonics, and then compared across stimulation frequencies and wavelet noise.

A 5 (wavelet noise) by 3 (stimulation frequency) repeated-measures ANOVA was performed on oddball response amplitude. Effects were then decomposed using paired comparisons to reveal where the differences occurred.

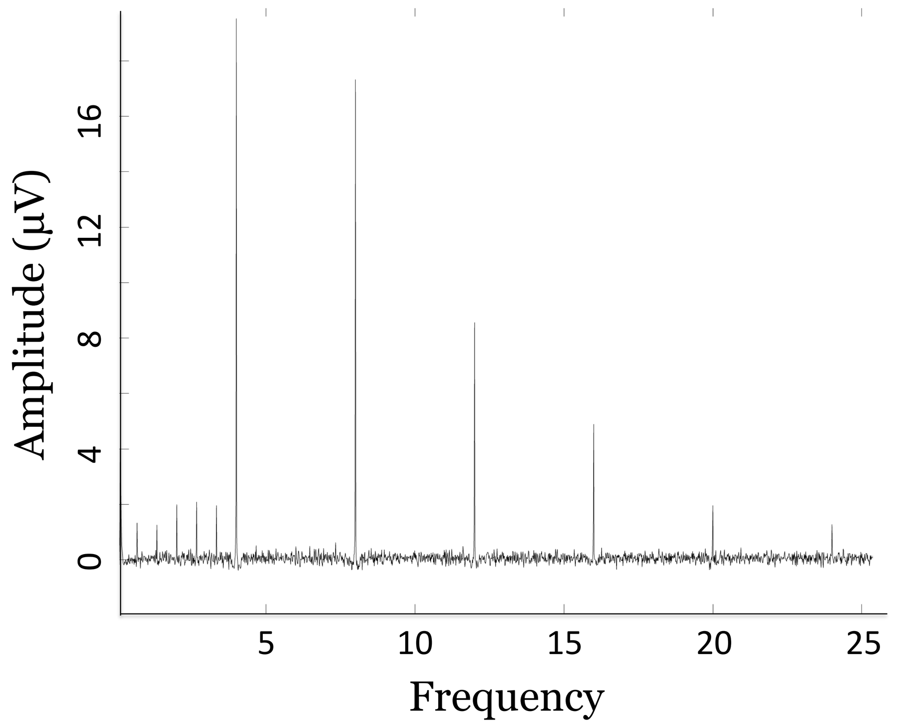

Figure 3. Z scored amplitudes in the Fourier Frequency Domain for all decomposition levels at 4Hz

Results

Data yielded significant main effects of wavelet noise, $F(4, 76) = 23.83$, $p < .001$, $\eta^2 = .56$ and stimulation frequency, $F(2, 38) = 3.91$, $p = .03$, $\eta^2 = .17$. Post-hoc analysis showed significant difference between every level of wavelet noise, all $ps < .05$, except between 10-15% and 15-20% as well as a significant difference between the 4Hz and 6Hz presentation rates, $t = 14.18$, $p = .014$, $d = 3.17$. The interaction between frequencies and decomposition level was not significant $F(8, 152) = .78$, $p = .620$, $\eta^2 = .04$.

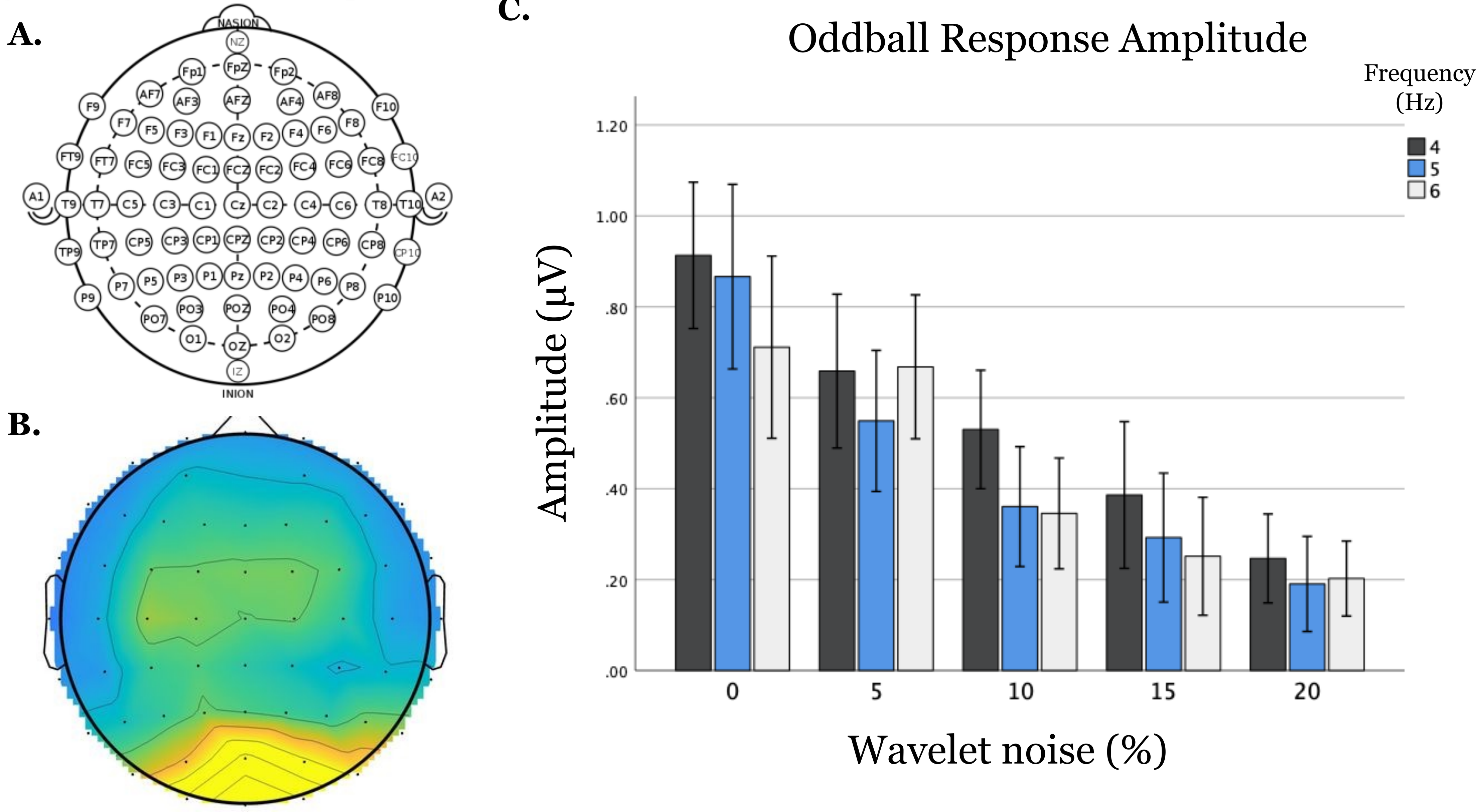

Figure 3. A. EEG system and electrodes placement. **B.** Scalp map of z scored amplitudes at the stimulation frequency of 4Hz for all decomposition levels. **C.** Amplitude of the SSVEP oddball response as a function of wavelet noise (error bars: 95% confidence interval).

Discussion

Results suggest that the optimal presentation frequency to process individual face identity is 4Hz. Interestingly, this frequency coincides with the N250 component often found in ERP studies to be the earliest identity-specific component[4,5]. Amplitude measures also varied inversely with the level of wavelet face noise, demonstrating a parametric neural synchronization. Finally, the effects found with the decomposition level demonstrated that the SSVEP signal is very sensitive to noise, as even small amounts led to significant differences in the amplitude of the signal.

References

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