

Supplementary Material for:

Effects of Formant Proximity and Stimulus Prototypicality on the Neural Discrimination of Vowels: Evidence from the Auditory Frequency-Following Response

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S.1 Speech Synthesis

The stimuli were synthesized using the Variable Linear Articulatory Model (see Ménard *et al.* (2004). This model is based on a five-formant cascade synthesis system (Feng, 1983). The source was a pulse train generated by the Liljencrants-Fant model (Fant, Liljencrants, & Lin, 1985). The parameters related to the source (glottal symmetry quotient and open quotient) were equal to 0.8 and 0.7, respectively. The value of the first bandwidth (B_1) was calculated according to Fant (1972). So, as a result, there might be differences in harmonic amplitudes, but this is due to the combination of models.

S.2 Acoustic Description of the Speech Stimuli

Prototype	F_1	F_2	F_3	F_4	F_5	B_1	B_2	B_3	B_4	B_5
French	275	790	2522	3410	4159	85	30	35	20	35
English	275	979	2522	3410	4159	85	30	35	20	35

Values of the lower formants (1-5) and their corresponding bandwidths for the less-focal/English /u/ and more-focal/French /u/ prototypes.

S.3 Acoustic and Neural Waveforms for Each Vowel Stimulus

Each vowel stimulus was 100-ms long with a 50-ms onset/offset ramp and had a mean F_0 (or first harmonic, H1) of 130 Hz. Acoustic and neural FFR waveforms for each vowel are shown below in Figure S1.

32 S.4 Analysis of the Neural Encoding of the Fundamental Frequency (F_0)

33 To assess the neural encoding of the fundamental frequency (F_0), we performed a 2 \times 2 repeated
34 measures analysis of variance (Vowel Type [less/focal/English /u/ vs. more focal/French /u/] \times
35 Condition [standard vs. deviant]) on the power (mV²) values in the frequency region
36 corresponding to F_0 (around 135 Hz). The results (shown in Figures 2B [in the manuscript] and
37 S2 [below]) revealed a highly significant main effect of Vowel Type [$F(1,18)=11.538, p=0.003,$
38 $\eta^2_p=0.391$], such that there were greater power values observed for the less-focal/English
39 prototypic /u/ (mean=2199.41; 95% CI [1784.33 2614.49]) compared to the more-focal/French
40 prototypic /u/ (mean=1321.32; 95% CI [969.56 1673.08]). The main effect of Condition did not
41 reach statistical significance [mean_{Standard}=1867.96, mean_{Deviant}=1652.77; $F(1,18)=3.965,$
42 $p=0.062, \eta^2_p=0.181$]. There was also no significant interaction [$F(1,18)=0.056, p=0.816,$
43 $\eta^2_p=0.003$]. Taken together, these results indicate that there is more robust neural encoding of F_0
44 for the less-focal but more prototypical exemplar of the /u/ category.

45 While it may be tempting to conclude that this reflects an enhancement in the neural
46 processing of auditory patterns that are more typical in the native-language (Kuhl & Iverson, 1995;
47 Kuhl *et al.*, 2008), these findings are equivocal. Closer inspection of the spectral slices of the
48 stimuli (shown in Figure 2A) indicate that the F_0 values are actually different between the two
49 vowel tokens. In addition, the spectral peak corresponding to F_0 is attenuated in the more-
50 focal/French prototypic /u/ compared to the less-focal/French prototypic /u/. Thus, in the absence
51 of cross-language data from both English- and French-speaking listeners, we cannot draw firm
52 conclusions about whether the enhanced encoding of F_0 for the less-focal/English /u/ prototype is
53 attributable to physical differences in the stimuli and/or long-term linguistic experience.

54 **Supplementary References**

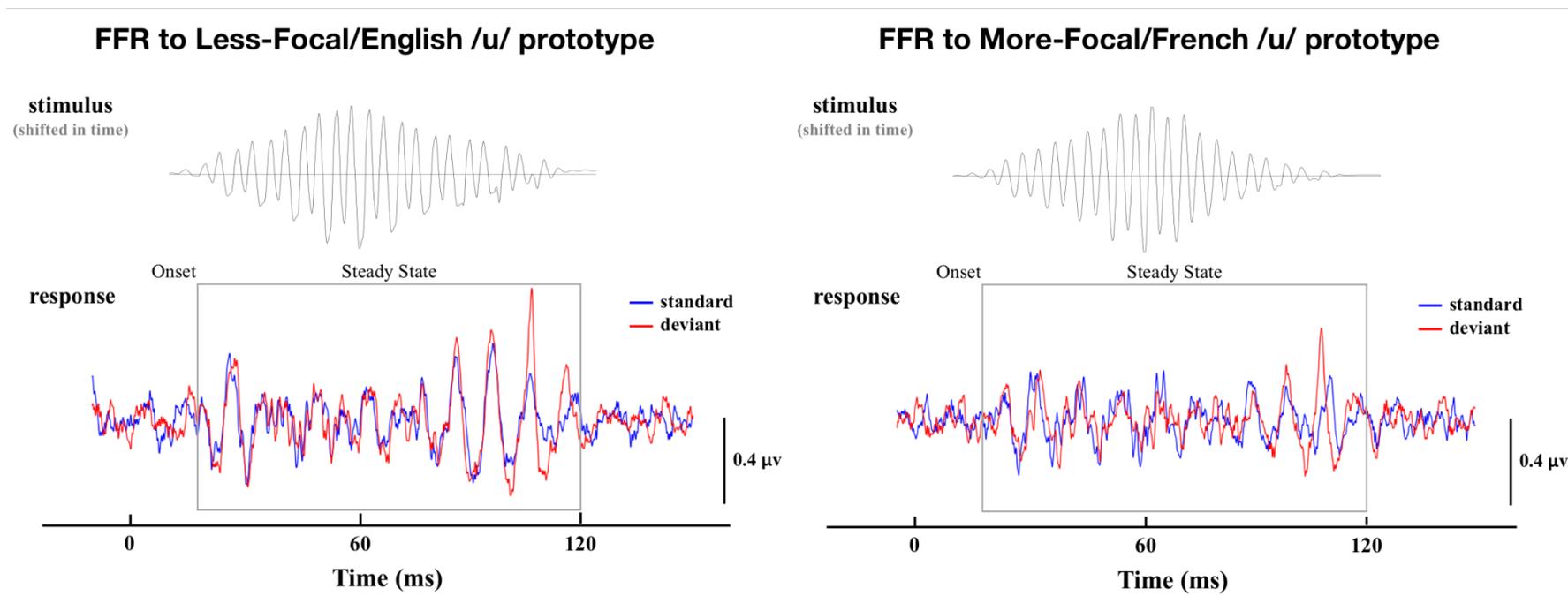
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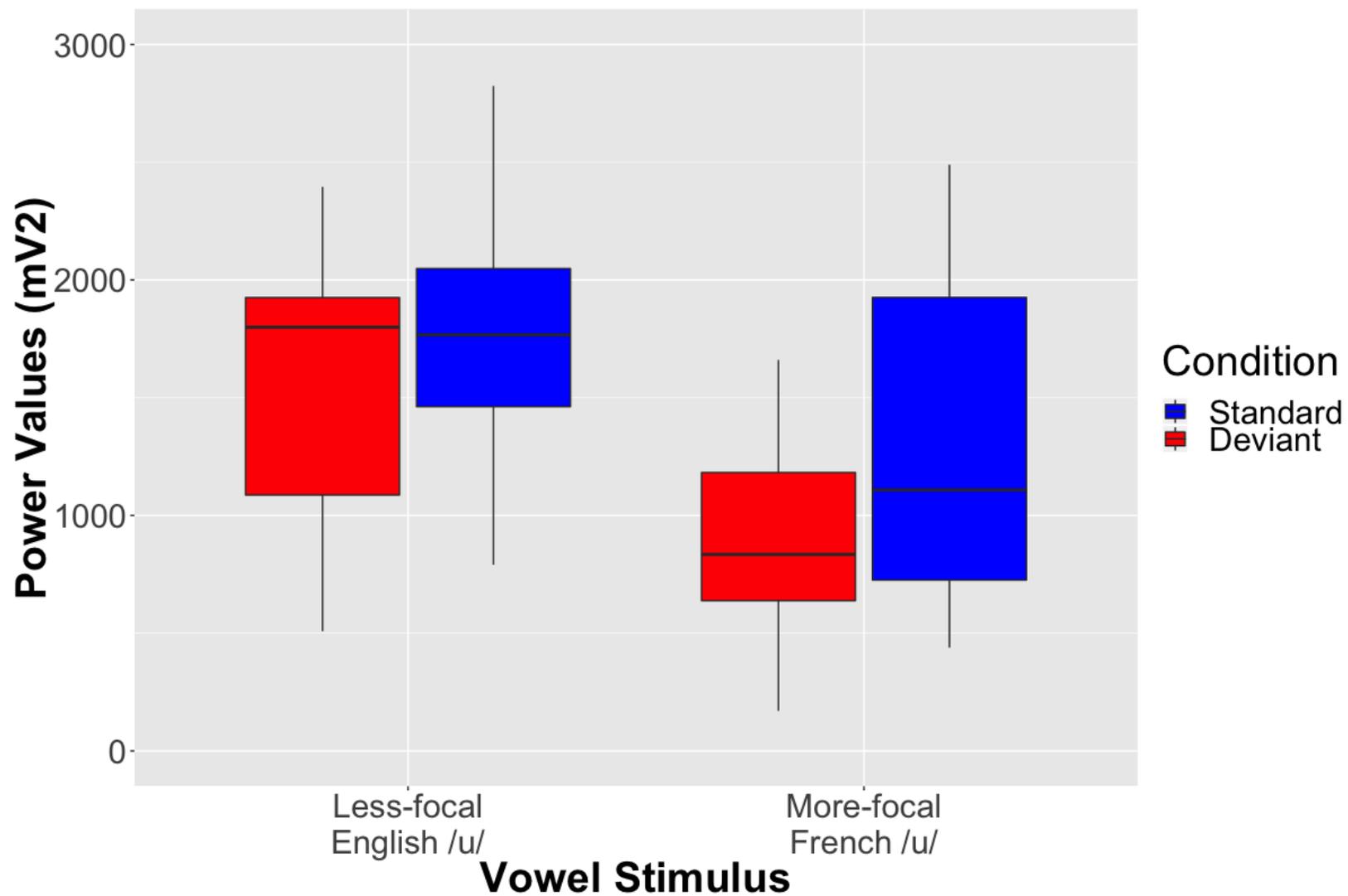
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Stimulus and FFR Waveforms



70 **Figure S1:** Stimulus (top) and neural response (bottom) waveforms for the two vowel stimuli (less-focal/English /u/ prototype vs. more-
71 focal/French /u/ prototype).



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74 **Figure S2:** Boxplots of the mean power (mV2) values at the frequency region corresponding to the fundamental frequency (F_0) for each
 75 stimulus (less-focal/English /u/ prototype vs. more-focal/French /u/ prototype) as a function of condition (standard vs. deviant).