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Supplementary Materials for

A speech envelope landmark for syllable encoding in human superior temporal gyrus

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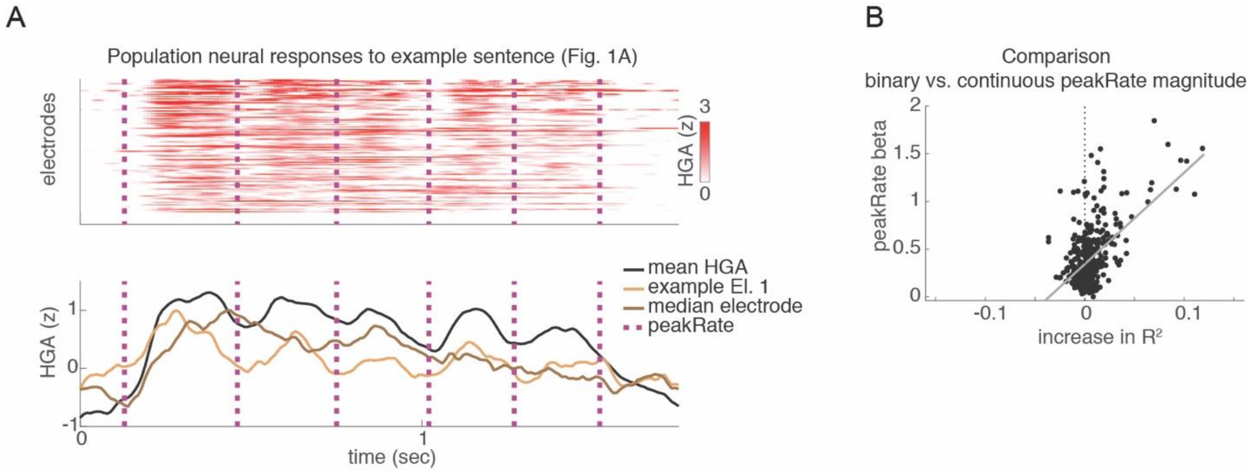

Fig. S1. Comparison between continuous envelope model and sparse landmark models. A. Top: Single electrode responses to example sentence 1 with respect to peakRate latency. Bottom: Average response across all electrodes, neural response of example electrode E1 from Fig. 1 and response of an electrode with median model R2. B. Comparison between a temporal receptive field model that only encodes the latency of peakRate with binary peakRate magnitude (i.e. peakRate is always 0 or 1) to a model that also parametrically encodes peakRate magnitude (i.e. peakRate varies between 0 and 1). For electrodes with strong encoding of peakRate, peakRate magnitude explains up to 10 % of additional variance.

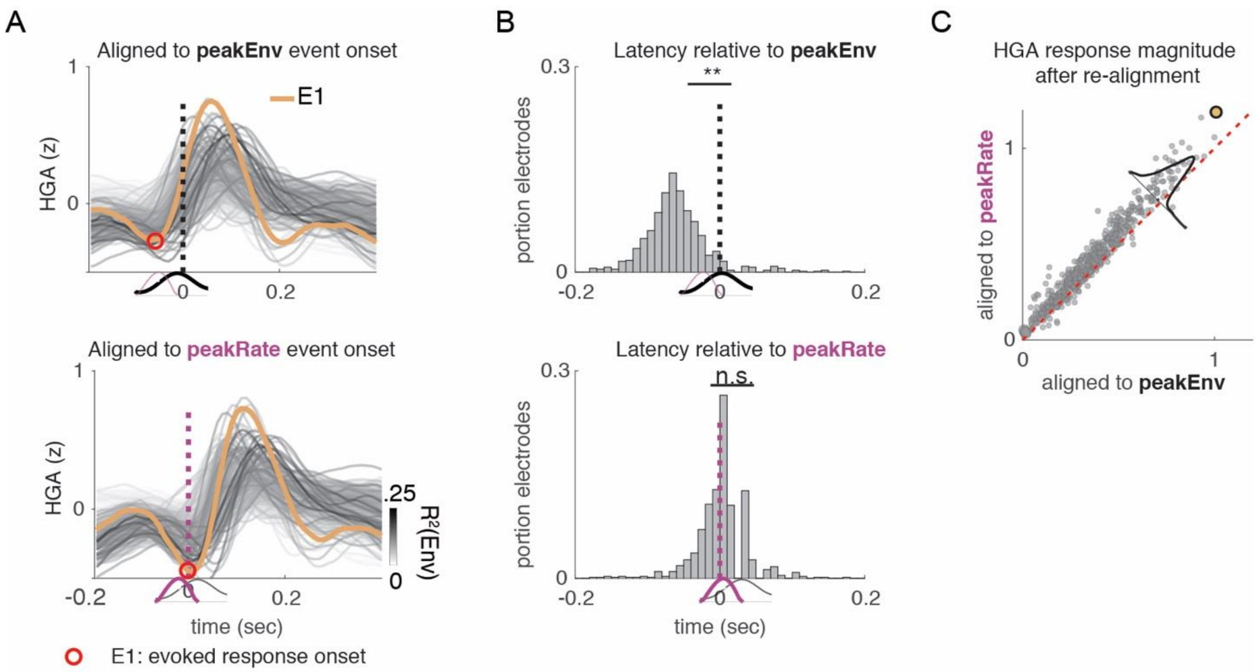

Fig. S2. Segmentation of neural responses to naturally produced sentences (TIMIT) around peakEnv and peakRate events. A. Single electrode neural responses realigned and averaged across all peakEnv (top) or peakRate (bottom) events. Realignment shows that neural response onset is prior to peakEnv events but temporally aligned to peakRate events (bottom). B. Distribution of latency between trough in neural response and peakEnv (top) and peakRate (bottom) events. C. Magnitude of average neural response in alignment to peakEnv vs. peakRate. Response magnitude is larger for alignment to peakRate than to peakEnv. Latency and response magnitude analyses support peakRate encoding over peakEnv encoding.

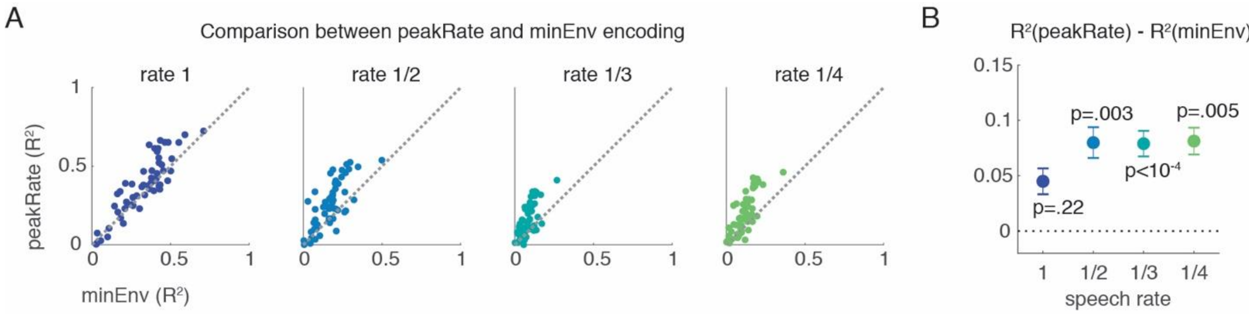

Fig. S3. Comparison between neural response predictions based on peakRate and minEnv models for slowed speech. A. Across all electrodes, peakRate model outperformed minEnv model. B. Average difference in model R^2 increases with speech slowing. PeakRate is thus a better predictor of neural activity than minEnv.

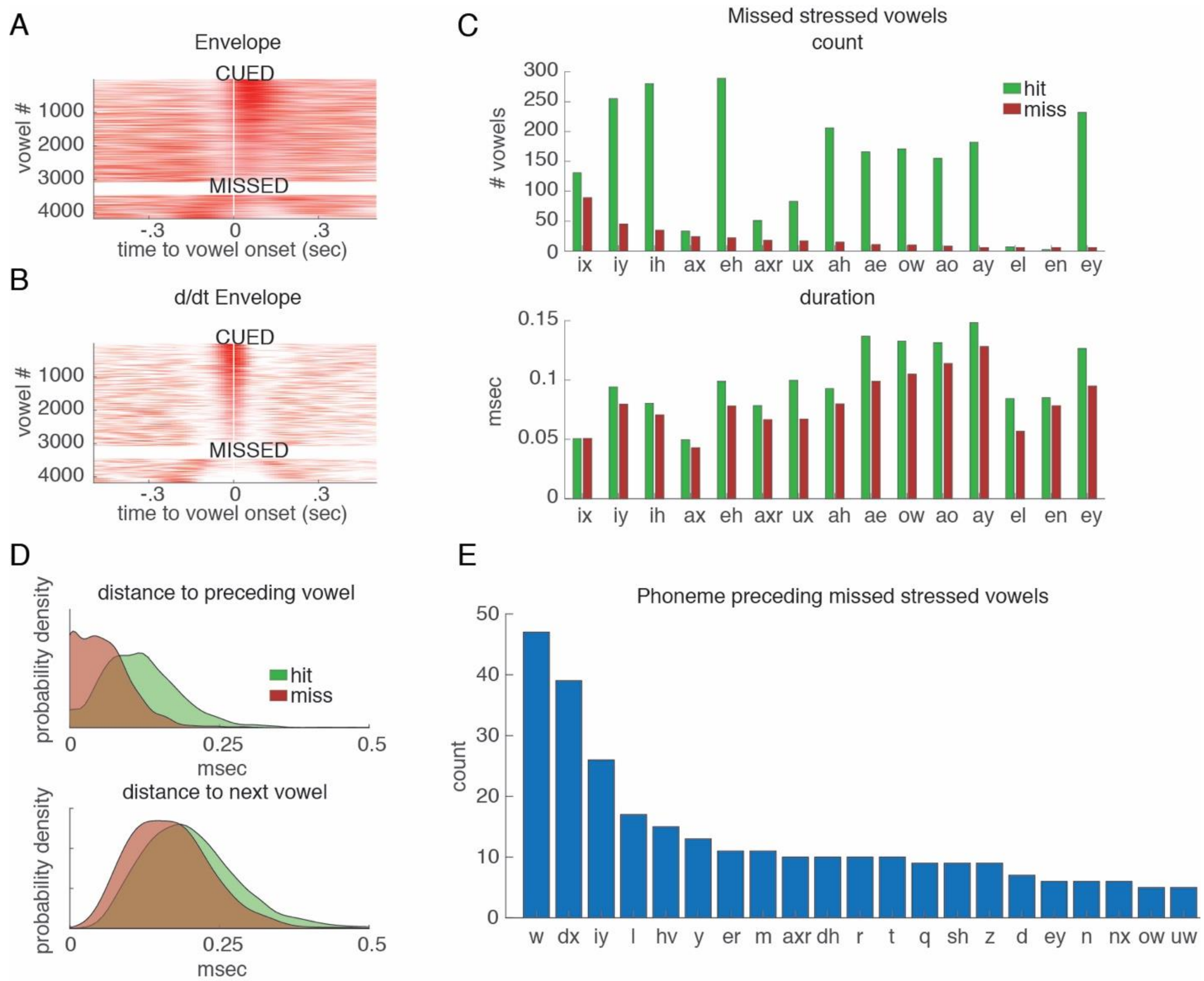

Fig. S4. Stressed vowels missed by peakRate. A. Normalized speech envelope time-aligned to vowel onsets. For vowels cued by peakRate, envelope peaks shortly after vowel onset, whereas for vowels that are not cued, the envelope peaks shortly before vowel onset, i.e. a sound with higher intensity precedes the envelope. B. Normalized rate of amplitude change, time-aligned to vowel onsets peaks (i.e. peakRate occurs) on vowel onset for cued vowels, but is earlier for un-cued vowels, again showing that un-cued vowels are preceded by another high intensity sound. C. Top: Identity of stressed vowels that were cued or missed by peakRate, plotted all vowels that were missed at least 5 times in the TIMIT stimulus set. Bottom: Duration of cued and missed vowels. Missed vowels are shorter than cued vowels. D. Distance to preceding and next vowel. Missed vowels occur shortly after the preceding vowel. E. Phonemes that precede missed stressed vowels. Most frequently, missed vowels are preceded by a /w/.

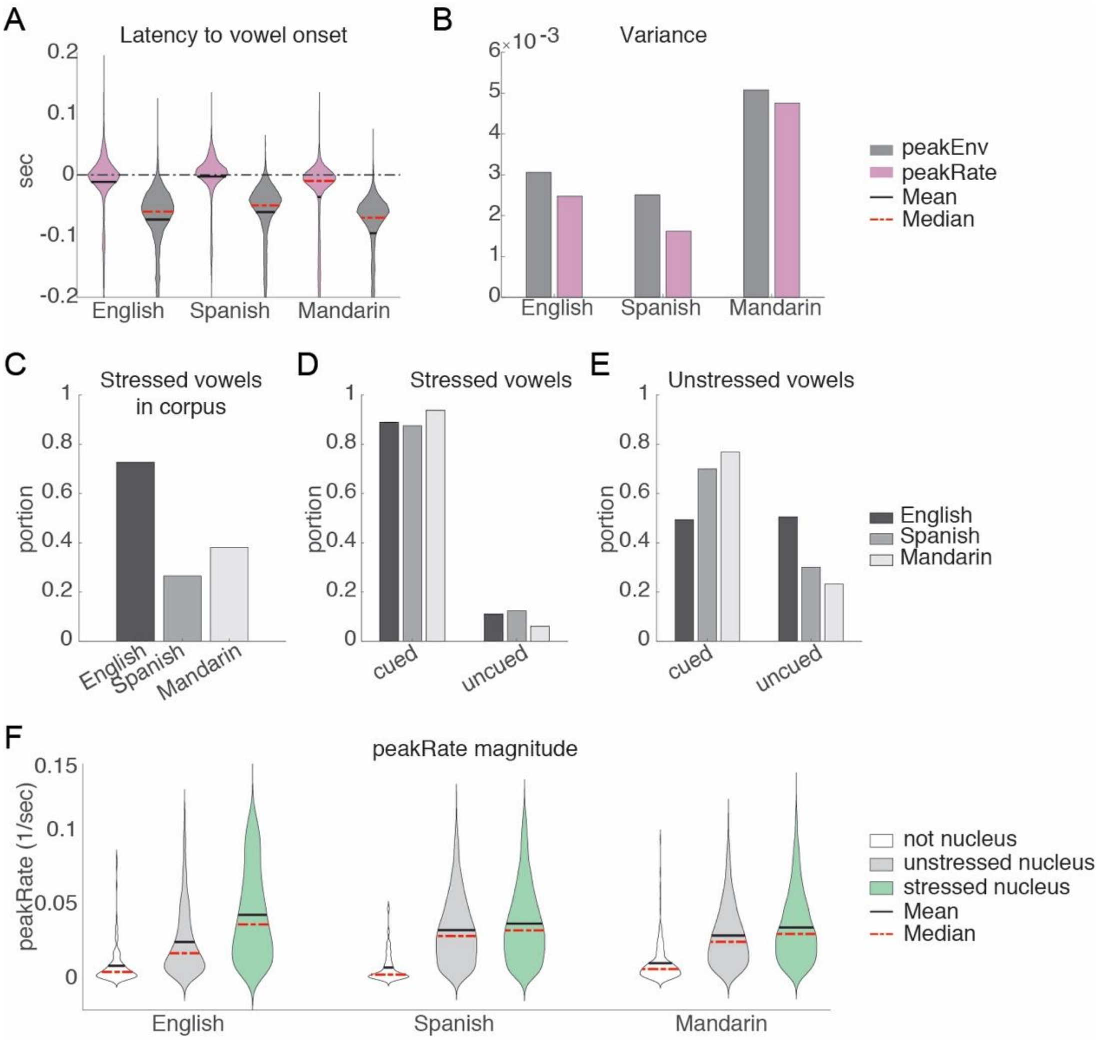

Fig. S5. Cross-linguistic analysis of peakRate and vowel onset co-occurrence. A. Distributions of latency between vowel onsets and peakRate events (purple) and peakEnv events (black). Across languages, peakRate, but not peakEnv, events closely coincide with vowel nucleus onsets. B. Variance of the distributions in A. peakRate is the better cue to vowel nucleus onset across languages. C. Portion of vowels that carry lexical stress by corpus. D. Portion of stressed vowels that are cued by peakRate events. E. Portion of unstressed vowels that are cued by peakRate. F. Distribution of peakRate magnitude for peakRate events that cue stressed vowels (green), unstressed vowels (grey), and consonants (white).

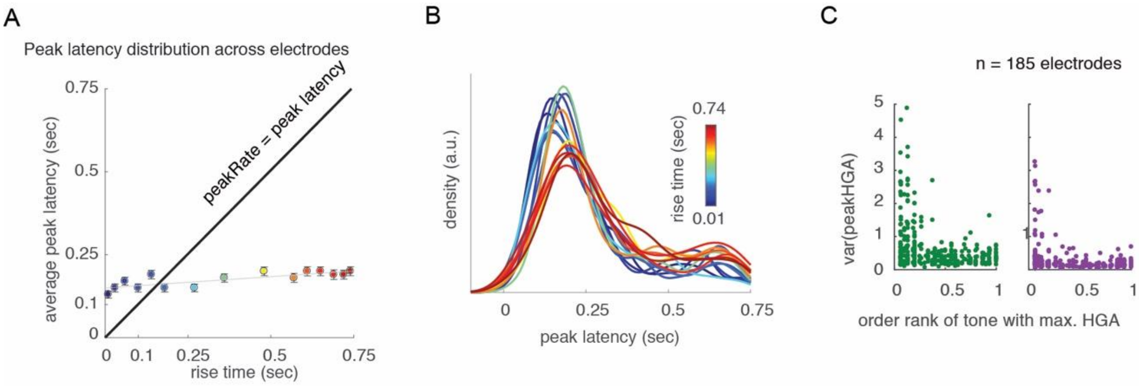

Fig. S6. Latency of neural response peaks as function of ramp rise time in amplitude-modulated tones. A. Peak latency as function of ramp rise time. For intermediate and long rise time the neural response peaks earlier than the ramp reaches maximal amplitude. B. Peak latency distribution across electrodes as a function of rise time. C. Variance in peakHGA across rise time values correlates with rank order of rise time that induced maximal peakHGA across all risetimes. This shows that on all electrodes where neural response magnitude differed as function of ramp rise time, encoding was monotonical with largest responses for short rise times.

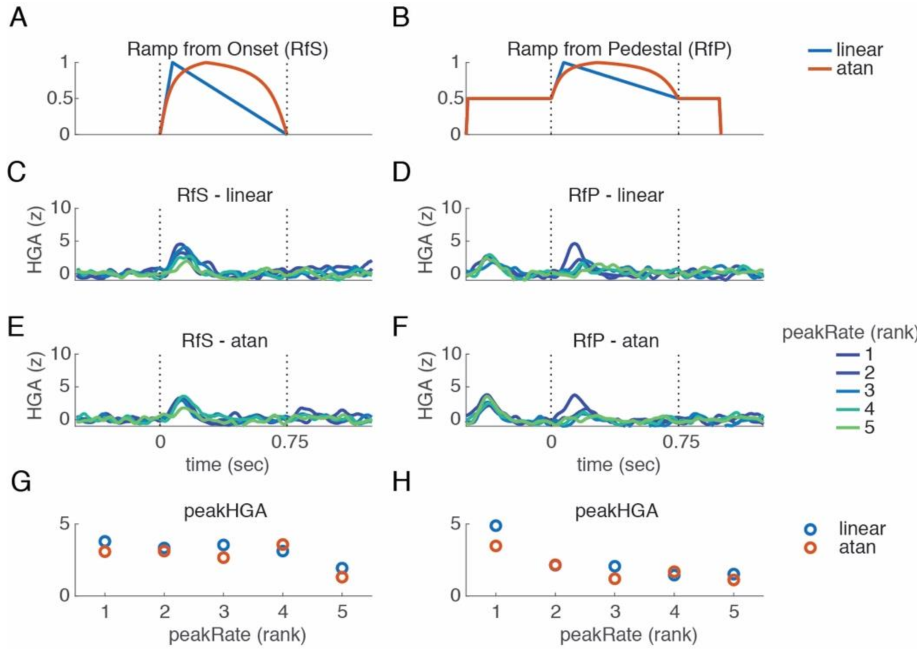

Fig. S7. Single-electrode responses to linear and sigmoidal ramp tones. A. Example ramp from silence tones with linear and sigmoidal rises, matched on peakRate at stimulus onset. Five different peakRate values were used in both conditions. B. Same as A for ramp from pedestal condition. C+D. Neural responses to linear rise ramps starting from silences (C) and pedestal (D). Color codes for peakRate (1 – fastest, 5 – slowest). E+F. Neural responses to sigmoidal rising ramps starting from silences (E) and pedestal (F). G+H: Magnitude of neural response as function of peakRate value. Neural responses did not differ between linear and sigmoidal onsets.

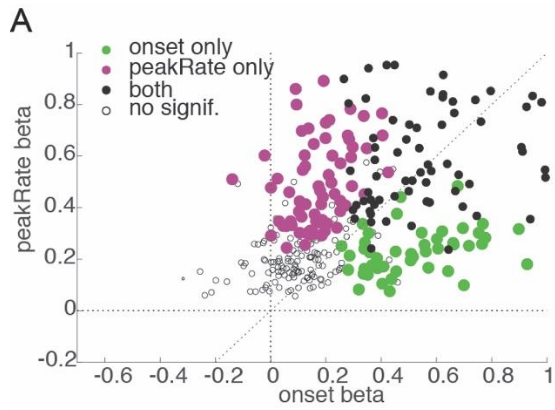

Fig. S8. Independent and joint encoding of peakRate and other speech features. A. Scatter plot of onset and peakRate betas. Electrode color indicates significance of peakRate and onset betas.

Table S1. Participants' details.

Patient ID	Age	Gender	Handedness	grid side	Seizure Foci	Resection Site	natural speech	slow speech	AM-tones
1	33	F	R	R	R Superior frontal gyrus	R Superior frontal gyrus	x	-	x
2	28	M	R	L	L Ant Temporal Lobe	L Ant Temporal Lobe	x	-	x
3	37	M	R	L	L Ant Temporal Lobe	L Ant Temporal Lobe	x	-	x
4	20	M	R	R	R Hippocampus	RNS	x	-	x
5	22	M	R	R	R supramarginal gyrus	R Ant Temp Lobe	x	-	x
6	40	F	R	R	R Rolandic Cortex	RNS	-	-	x
7	36	M	R	L	L Medial Temporal Lobe	RNS	x	-	x
8	59	M	R	L	L Temporal Lobe	L ant Temp Lobe	x	-	x
9	24	M	R	R	R Basal Temp-Occipital lobe	R Post Temp Lobe	x	x	-
10	40	N	R	R	R Ant Lobe	R Ant lobe sparing post STG	x	x	-
11	38	M	R	L	L Temp Lobe	L Amygdala/Hippocampus	x	x	-
12	19	M	R	R	R Frontotemporal Lobe	R Ant Temp and Frontal Lobe	x	x	-