



# Mapping of critical prosodic and phonetic networks in post-stroke apraxia of speech

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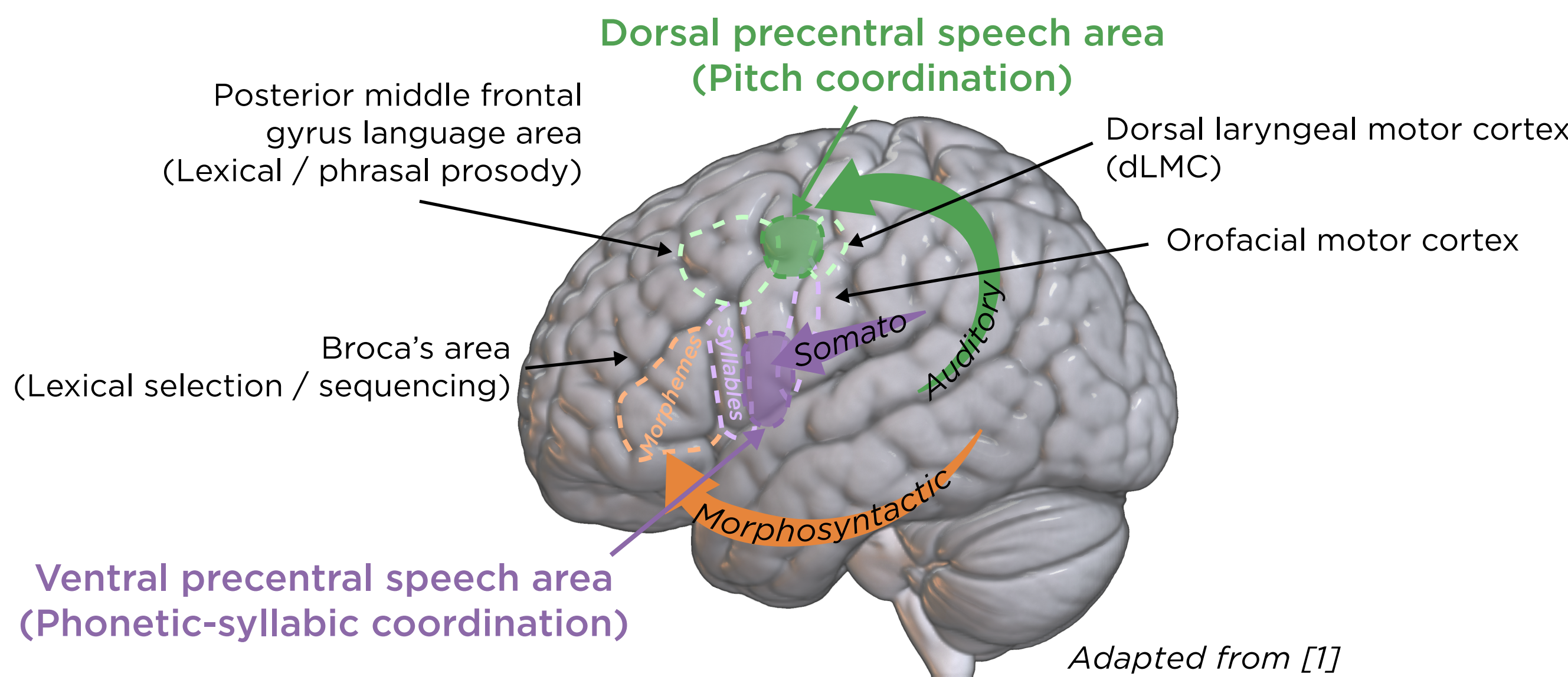
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## Background

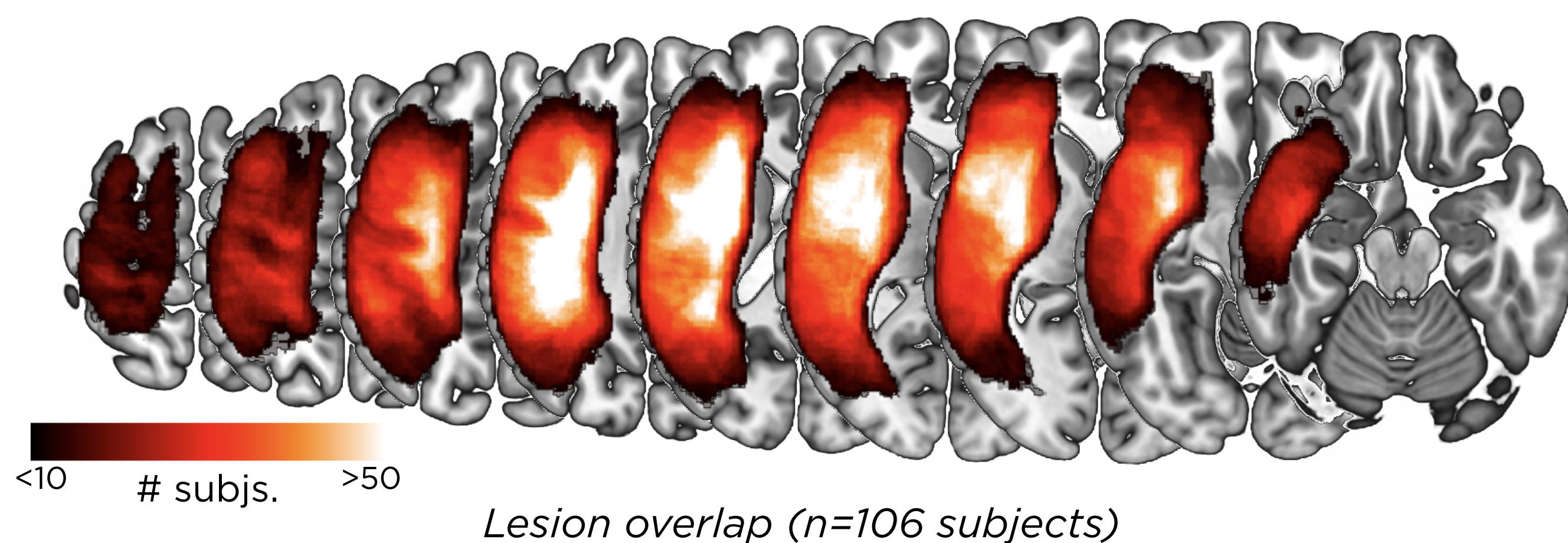
- **Beyond Broca** — New neuroanatomical model specifies two pathways of speech motor coordination:<sup>[1]</sup>
  - Dorsal precentral speech area (**dPCSA**): laryngeal control, **prosodic** function, connectivity to auditory cortex
  - Ventral precentral speech area (**vPCSA**): supralaryngeal control, **phonetic** function, connectivity to inferior parietal
- In primary progressive AOS, there is a recent prosodic and phonetic subtype split:<sup>[2]</sup>
  - **Prosodic** PPAOS: difficulty with syllable segmentation, speech rate
  - **Phonetic** PPAOS: distorted sound additions, substitutions



## Research Questions

1. Is **post-stroke AOS** separable into **prosodic** and **phonetic** subtypes?
2. Does the **neuroanatomy of prosodic and phonetic impairment** align with the **dual-motor coordination model**?
  - Use Apraxia of Speech Rating Scale (**ASRS**<sup>[3,4]</sup>) scores from the **POLAR**<sup>[5]</sup> study

Pathology	#	%	Characteristic	Mean ± SD
Control (WNL)	20	16.3	Age at stroke onset	55.7 ± 11.8
Aphasia only	35	28.4	Age at assessment	60.4 ± 10.8
Aphasia & dysarthria	7	5.7	Months post stroke onset	54.9 ± 54.8
Aphasia & AOS	39	31.7	WAB Aphasia Quotient	65.7 ± 25.2
Aphasia, dysarthria, & AOS	22	17.9		



## Network-based LSM

**Step 1:** Identify **candidate regions** for modeled behavior via permutation test

For each atlas region...

1a. Multivariate linear regression

$$\hat{y} = \beta_0 + \beta_1 x_1 + \beta_2 x_2$$

1b. Calculate  $p$ -value for individual region

$$p = \frac{1}{N} \sum_{i=1}^{N=2000} \mathbb{I}(\beta_{1,i}^{(\text{perm})} \geq \beta_{1,i}^{(\text{obs})})$$

Do this many times, shuffling ASRS scores

$p$  = proportion of permutations where the  $\beta_1$  coefficient is at least as large as the observed data's  $\beta_1$  coefficient

**Step 2:** Use cross-validation to calculate prediction error for all permutations of candidate regions

ROI	$p$	Candidate?	$\mathbb{P}_+(\{a, b, c\})$	Error = $\frac{1}{N} \sum_{i=1}^{N=123}  y_i - \hat{y}_i $	Beats univariate error? (2.1)
a	0.01	✓	a only	1.8	✓
b	0.04	✓	b only	3.4	✗
c	0.07	✓	c only	2.6	✗
d	0.58	✗	a + b	2.0	✓
			b + c	2.4	✓
			a + c	1.6	✓
			a + b + c	2.5	✗

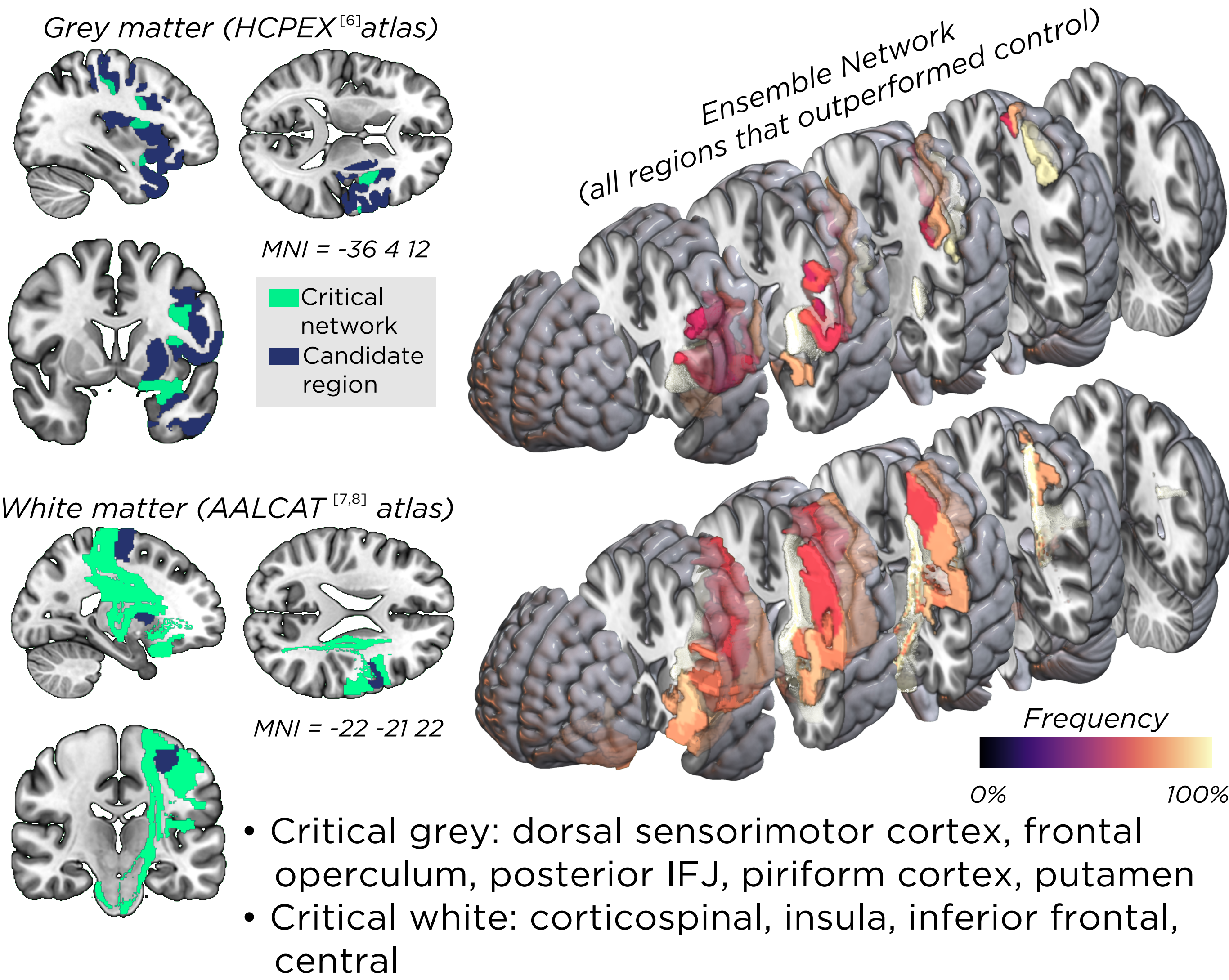
Candidate regions from Step 1

Set of candidate networks

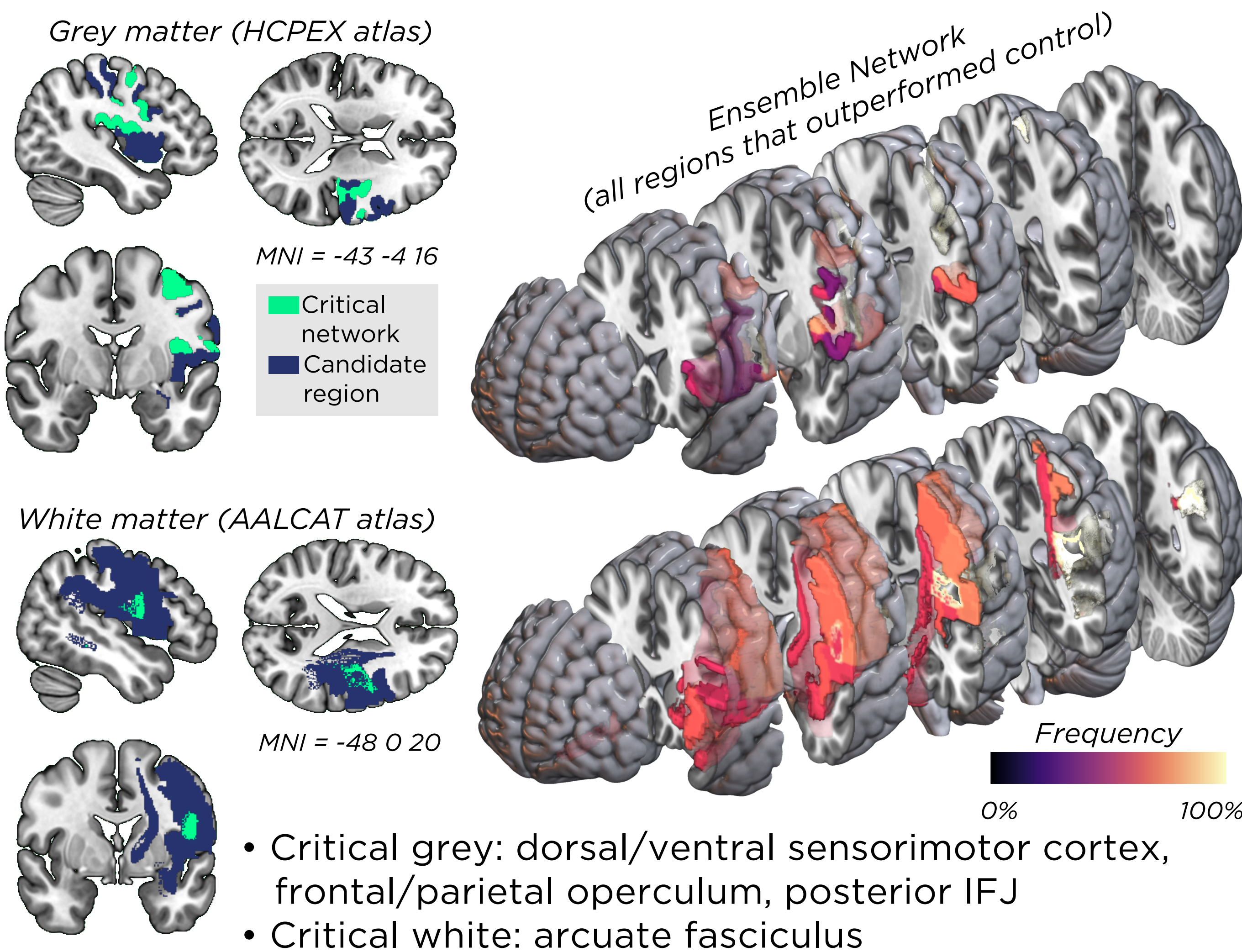
Outcome statistics:

- **Ensemble** of networks that outperform control & frequency of individual regions in this ensemble network
- **Critical network** = the single best set of regions (min. error)

## Mapping prosodic function



## Mapping phonetic function



- Critical grey: dorsal/ventral sensorimotor cortex, frontal/parietal operculum, posterior IFJ
- Critical white: arcuate fasciculus

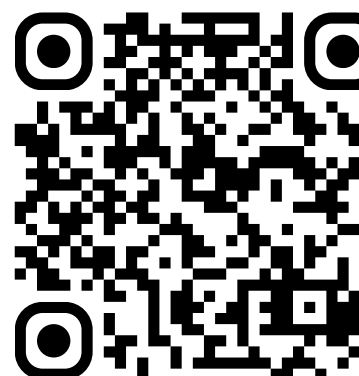
## Discussion

- Prosodic and phonetic subscores of ASRS localize to separate neural pathways:
  - Prosodic: Central sensory/motor areas, auditory/insular connections, cerebellum and subcortical motor nuclei
  - Phonetic: Central sensory/motor areas, inferior parietal connections
  - However, dorsal/ventral divide isn't a perfect split of the functions
- Subtypes of AOS align with dual-motor coordination model
- Network maps stress importance of long-distance connections in supporting prosodic and phonetic function

## References

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