Common recruitment of neural resources for phonological working memory regardless of behavioral demands

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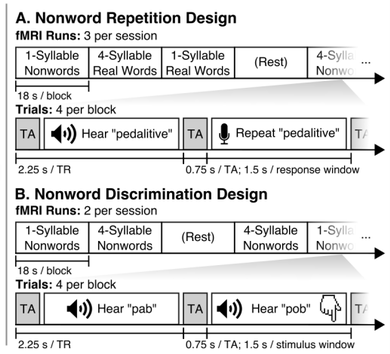
Summary

Phonological working memory (PWM) is the process of maintaining sounds important for **speech** and **language** in short term memory. This process is believed to be crucial for successfully acquiring **reading proficiency** and is often assessed using **nonword repetition** tasks. Here we aimed to identify, using functional magnetic resonance imaging (fMRI), brain regions in typically-developing adults that support PWM using tasks that closely reflect its clinical operationalization. **Participants completed two tasks during neuroimaging**: nonword repetition and nonword discrimination. We analyzed the overlap of the two tasks within individual subjects and found **(1) significant neural responses to the critical contrast of high vs. low PWM load in both tasks were supported by a similar set of regions closely resembling those involved in speech** (i.e., superior temporal gyrus, planum temporale, motor cortex, and cerebellum) and **(2) within those regions, the voxel-wise patterns of load-related activation were highly correlated between the two tasks**. These results suggest that processing increased PWM load involves recruitment of a consistent set of neural regions known to be integrally involved in speech, regardless of the specific behavioral demands of the working memory task.

Methods

Participants: 20 fluent English-speaking adults (12 female; age 19-32 years, *M* = 24.1 years)
Auditory Stimuli: 1-syllable (low PWM load) and 4-syllable (high PWM load) nonwords were generated to closely parallel the structural and statistical properties of English, as in the stimuli used clinically in the Children's Test of Nonword Repetition (CNRep; Gathercole et al. 1994; Gathercole & Baddeley 1996).
Imaging: Simultaneous multi-slice sparse acquisition fMRI was used during 3 runs of nonword repetition and 2 runs of nonword discrimination.

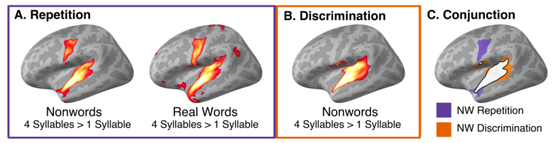


Behavioral Results

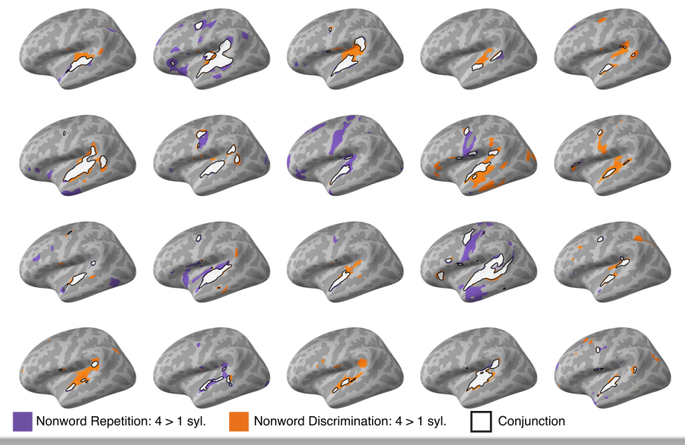
Behavioral Measure	1–Syllable	4–Syllables	Statistical Difference
Nonword Repetition Accuracy (% Correct)	98.12 ± 0.022	97.80 ± 0.027	$t(19) = 0.43$ $p = 0.67$
Real Word Repetition Accuracy (% Correct)	99.37 ± 0.010	100. ± 0.	$t(19) = -2.85$ $p = 0.010$
Nonword Discrimination Accuracy (% Correct)	94.79 ± 0.049	95.73 ± 0.041	$t(19) = -0.95$ $p = 0.35$
Nonword Discrimination Reaction Time (ms)	941 ± 106	1153 ± 103	$t(19) = -23.61$ $p < 10^{-14}$

Results and Intersubject Variability

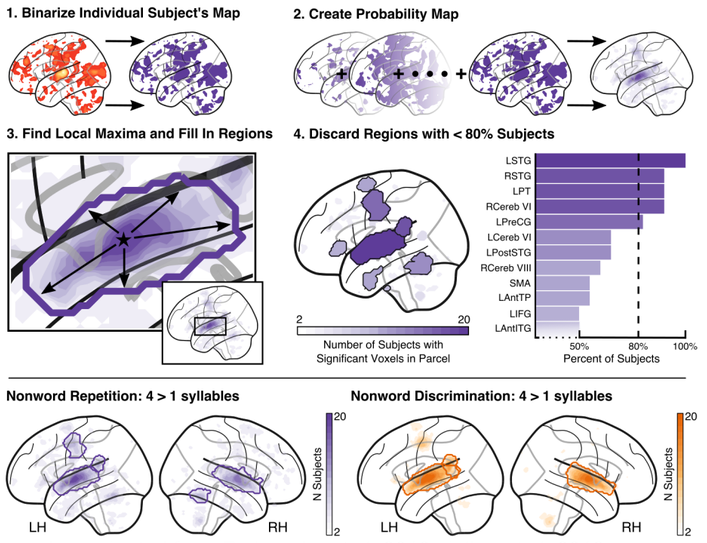
Univariate Group Maps: Voxel threshold $p < 0.01$, cluster FWE $p < 0.05$.



All Subjects' Conjunction Maps: Voxel threshold $p < 0.01$, uncorrected.

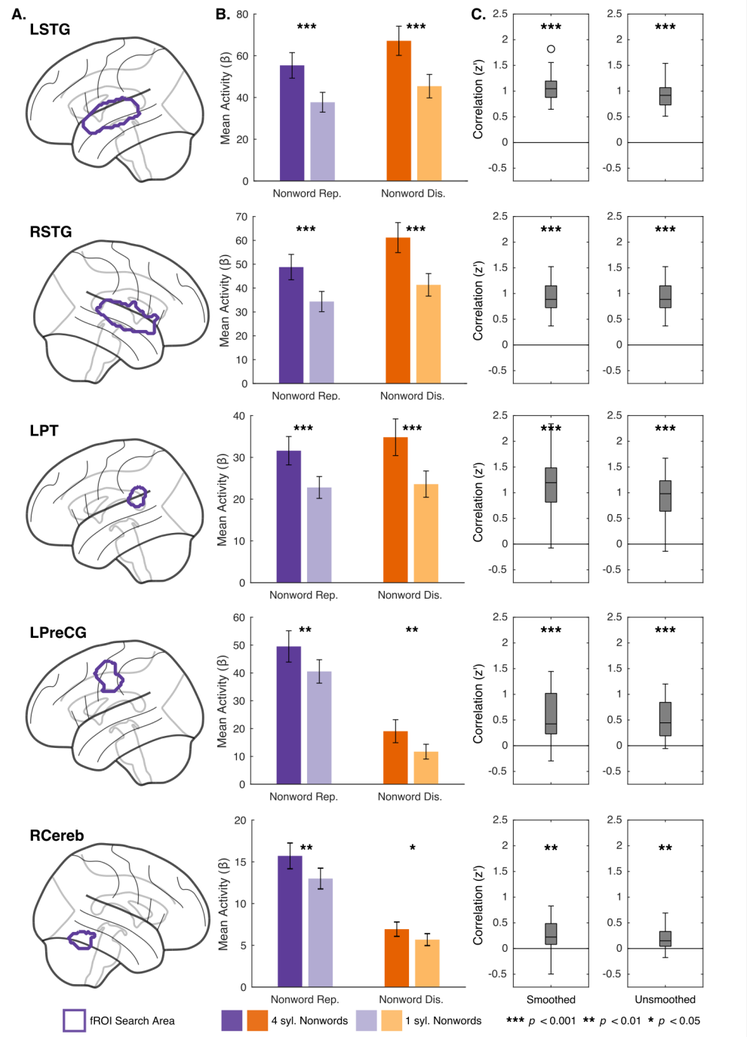


Constructing Data-Driven ROIs



Procedure adapted from Fedorenko et al. 2010; Julian et al. 2012.

Within-Subject Analyses



Functional regions of interest (fROIs) are defined in individual subjects as the top 10% of voxels in the 4-syllables > 1-syllable contrast maps from nonword repetition within the **(A)** broad ROI. **(B)** Response magnitudes are measured in *independently* defined fROIs, all statistics Bonferroni corrected for number of regions. Nonword repetition activity measured in fROIs defined by independent splits of nonword repetition, nonword discrimination activity measured in fROIs defined by all runs of nonword repetition. **(C)** Voxel-wise correlations were calculated between the contrast maps from both tasks across the broad ROI in smoothed and unsmoothed data.

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