Temporal and Prefrontal Cortical Contributions to Phonological Working Memory for Words and Pseudowords

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Abstract

We investigated the neural bases of phonological working memory for auditory words and pseudowords, and how these relate to clinical measures of phonological working memory, in a parametric design with healthy adults.

There was increasing recruitment of bilateral superior temporal and left prefrontal cortices as a function of syllable length in auditory pseudoword discrimination. Increasing syllable length in real words recruited only increasing activation in left superior temporal cortex.

Background

<u>Phonological working memory</u> underlies the ability to flexibly process verbal information in a goal-directed manner and is fundamental to successful language acquisition.

<u>Pseudoword repetition:</u> An effective assessment of phonological working memory – listeners must parse the incoming speech signal for phonemic units, store them temporarily, and repeat them (Gathercole et al., 1994).

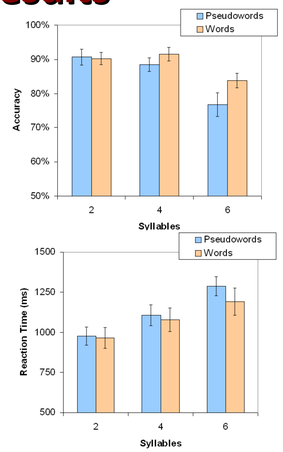
<u>Deficits in phonological working memory:</u> Frequently exhibited by children with SLI – an unexplained difficulty in learning language with otherwise unaffected development – in particular, difficulty repeating pseudowords (Weismer et al., 2000).

<u>Pseudoword discrimination</u>, compared to repetition, requires similar cognitive processes, and is more conducive to an MRI environment than overt vocalizations (Strand et al., 2008).

<u>Current Study</u>: We used an fMRI pseudoword discrimination task to map the brain network associated with typically developed phonological working memory in adults, and relate functional activation to standardized behavioral measures of phonological working memory

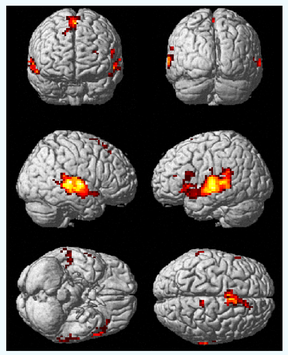
Understanding typically developed phonological working memory systems will allow us to better understand how this network comes online during normal child development, and its disturbance may be associated with language learning impairments like SLI.

Results

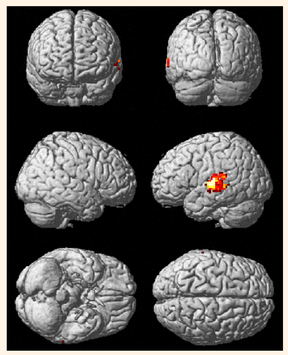


<u>In-Scanner Performance</u>
Marginally more accurate (p=0.067) and faster (p=0.052) for real vs. pseudowords.
Less accurate (p<0.001) and slower (p < 0.001) for longer syllables

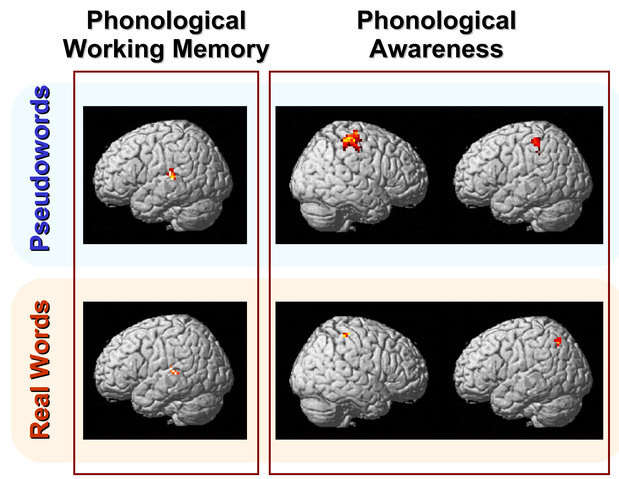
Pseudowords



Real Words



<u>Parametric Activation</u>:
Increasing syllabic length was associated with increasing activation in bilateral STG, left IFG, and bilateral SMA for pseudowords, and only left STG for real words (p < 0.001, FDR < 0.05, ET > 10).



<u>Cognitive / Behavioral Correlations</u>: Functional activity in left STG correlated significantly with participants' phonological working memory (CNRep; p < 0.001, ET > 10) for both real and pseudowords. Activity bilaterally in superior parietal lobe correlated with phonological awareness (CTOPP Elision & Blending; p < 0.001, FDR < 0.05, ET > 10)

Methods

<u>Participants</u>
17 right-handed, native English-speaking adults, who reported no speech, hearing, linguistic, neurological, or psychological deficits or disorders.

<u>Auditory Stimuli</u>
Real Words: **90 tokens of real English words; 2, 4, or 6 syllables in length.**
Pseudowords: **90 tokens of 2, 4, and 6 phonologically and phonotactically possible English words (e.g. *tector, klamic, crimipism, shagonazle, creopleastify, pacheoranian*)**

<u>Task</u>
Participants discriminated pairs of real- or pseudoword stimuli (50% same, 50% different). Mismatched pseudoword pairs differed by 1 phoneme and differences resembled pseudoword repetition errors made by children with SLI.

<u>fMRI Acquisition Parameters</u>
Siemens Trio 3T MRI scanner, 12-channel head coil, TR = 6, TA = 2 (sparse sampling), 32 axial slices, whole head coverage, 3.125×3.125×5.200 mm voxels, 64×64 FOV.

<u>Data Preprocessing</u>
Functional timeseries data were realigned to correct for subject movement, submitted to motion and intensity artifact rejection, coregistered and normalized to an anatomical template, spatially smoothed at 6mm FWHM.

<u>Statistical Analysis</u>
Functional timeseries data were submitted to a parametric analysis to determine which voxels showed increasing activation with corresponding increasing syllable length. Results were FDR corrected for multiple comparisons. Participants' behavioral assessments were correlated with mean activation by condition.

References
Weismer et al., (2000). "Nonword repetition performance in school-age children with and without language impairment." *J.Speech Lang. Hearing Res.*, 43, 865-878.

Gathercole et al. (1994) "The children's test of nonword repetition: A test of phonological working memory." *Memory*, 2, 103-127.

Strand et al. (2008) "Phonological working memory with auditory presentation of pseudo-words: An event-related fMRI study." *Brain Research*, 1212, 48-54.

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