The rostral supplementary motor area supports the repetition of visually and auditorily presented pseudowords

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Introduction: In healthy right-handed individuals, repetition of auditorily presented pseudowords activates a left hemispheric network which maps auditory input onto motor-articulatory representations (Hickok and Poeppel, 2000; 2004). The network for the repetition of pseudowords relative to real words comprises left motor and premotor areas including the supplementary motor area (Saur et al., 2008). Our aim was to identify brain regions involved in the modality-independent (i.e. auditory and visual) repetition of pseudowords. We hypothesised to find increased activation in motor areas including the premotor cortex and the supplementary motor area.

Methods: 17 right-handed, healthy participants (10 females; age range: 21-30 years) underwent functional magnetic resonance imaging (fMRI) at 3 T (Philips, Best, The Netherlands) while overtly repeating blocks of visually and auditorily presented pseudowords or real words. The order of blocks was pseudorandomized and an interstimulus interval of 3-8 s allowed for an event related analysis. Preprocessing of the individual images included unwarping to account for movements due to overt articulation. For each modality and stimulus type, we identified regional increases in blood oxygen dependent (BOLD) signal relative to rest ($p < 0.001$, uncorrected). These contrast images were entered into a second level random effects analysis using a flexible factorial design. We used a conjunction analysis to identify brain regions processing modality-independent aspects of pseudoword relative to word repetition. We also computed a psychophysiological interaction (PPI) to assess changes in the effective connectivity within the modality-independent network for pseudoword repetition.

Results: The right rostral supplementary motor area (rSMA) was activated for the modality-independent repetition of pseudowords in comparison to real words (T-value = 3.92; see Fig.1A).
During pseudoword repetition, task-related activity in the right rSMA showed increased task-related coupling with activity in the ipsilateral primary motor cortex (M1; T-value = 3.60; Fig.1B) and contralateral (left) ventral premotor cortex (PMv; T-value = 3.52; Fig.1C).

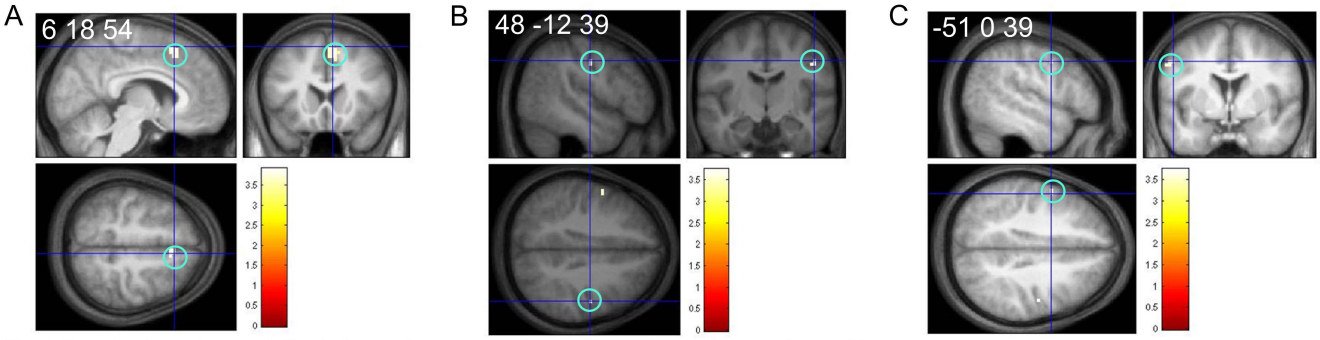

Fig.1 Results from the modality-independent comparison of pseudoword > word repetition.
A. Modality-independent conjunction for auditorily and visually presented stimuli for pseudoword > word repetition: Activation cluster in the right rostral supplementary motor area (rSMA; maximum: 6 18 54; MNI; T=3.92; p<0.001 uncorrected; inclusively masked with the main effect for auditory and visual pseudoword repetition [0.05 uncorrected]). B,C. Results from the PPI analysis: Areas showing increased task related coupling with activity in the right rSMA
B. Activation cluster in the right primary motor cortex (M1; maximum: 48 -12 39; MNI; T=3.60; p<0.001 uncorrected)
C. Activation cluster in the left ventral premotor cortex (PMv; maximum: -51 0 39; MNI; T=3.52; p<0.001 uncorrected)

Conclusions: Extending recent neuroimaging studies (e.g. Saur et al., 2008), the present results show that the rSMA is involved in the modality-independent repetition of pseudowords relative to words. The increased task related influence of rSMA on M1 and PMv during the repetition of pseudowords is compatible with a supervisory role of the rostral SMA on executive motor areas involved in overt language production.

References:

Hickok G, & Poeppel D (2000) Towards a functional neuroanatomy of speech perception. *Trends Cogn Sci 4*:131-138.

Hickok G, & Poeppel D (2004) Dorsal and ventral streams: a framework for understanding aspects of the functional anatomy of language. *Cognition 92*:67-99.

Saur D, Kreher BW, Schnell S, Kummerer D, Kellmeyer P, Vry MS, Umarova R, Musso M, Glauche V, Abel S, Huber W, Rijntjes M, Hennig J, & Weiller C (2008) Ventral and dorsal pathways for language. *Proc Natl Acad Sci U S A 105*:18035-18040.