Neural Systems Supporting Word Production Converge at the Level of Whole Word Phonology

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Introduction: Word production in the context of picture naming involves prelexical and lexical processing stages, the latter purported to include two substages, one for selection of a lexical-semantic representation and one for a lexical-phonological representation (Levelt et al., 1999). Imaging studies have demonstrated that neural systems engaged during prelexical stages are partially segregated depending on conceptual category. Results from a more recent study have shown that such segregation may propagate to structures engaged during lexical-semantic selection (Rudrauf et al., 2006). It has, however, not been established whether category effects persist at the stage of activation of the lexical-phonological representation, nor specifically whether activity in left posterior superior temporal gyrus (pSTG), implicated in whole word phonological access (Graves et al., 2007; Graves et al., 2008), displays effects of conceptual category. We performed an overt naming fMRI study, selectively targeting the interaction of conceptual category and lexical-phonological access using the production word frequency effect (WFE) (Oldfield and Wingfield, 1965). We expected to replicate the association of the production WFE with increased activity in the left pSTG and hypothesized that activity in this region would be independent of conceptual category.

Methods: Fourteen normal right-handed subjects (8 M, age range 21 - 44) were scanned on a Siemens 3T TIM TrioScanner. Subjects overtly produced names in response to color pictures of animals or man-made manipulable objects ("tools") presented in a hybrid event-block design. We analyzed the BOLD correlates of the word (lexeme) frequency of stimuli (cf CELEX lexical database, Baayen et al., 1995), which was variable and balanced across category. Presentation of each pictured entity (using different exemplars) was randomly repeated four times and orthogonalized with respect to runs. Scan-time performance was recorded using an MR-compatible microphone and a time-aware data acquisition system (Smyser et al., 2001). Imaging data were analyzed using the general linear model, with (log-transformed) word frequency and repetition modeled parametrically and nested within conceptual category. Group level analysis was performed using random effects and thresholded at p <0.05, corrected.

Results: Results for the WFE replicated previous behavioral and imaging findings. Analysis of response latencies revealed a significant WFE, with longer latencies associated with lower word frequencies (t(13) = 4.12, p <0.005). Imaging results showed increasing activity in left pSTG (-51 -16 +7) for naming as a function of lower word frequency. Well-established main effects for conceptual category were also replicated, with greater BOLD activity in visual regions for animals and in left inferotemporal, inferior parietal, and premotor regions for tools. There was, however, no main category effect in left pSTG, and as hypothesized, no interaction of conceptual category with word frequency in this region. Significant correlates of word frequency were found in left pSTG for both categories, and a conjunction analysis revealed nearly complete spatial overlap of activation in this region.
Conclusions: The partial segregation of neural systems involved with naming entities from different conceptual categories is not observed at the stage of lexical phonological access supported by left pSTG. This finding is consistent with convergence of word production systems at the point of whole word phonology.

References: