Information Processing Speed During Functional Neuroimaging of Sentence Comprehension

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This study continues previous work investigating the neural basis for grammatical and short-term memory components of sentence comprehension. We hypothesized that greater demands placed upon a third component, information processing speed in the form of a faster stimulus presentation rate, is shouldered by the caudate nucleus. To test this hypothesis, neural activity was measured with fMRI in 15 healthy, right-handed English-speakers as they determined the agent of the action in sentences with subject-relative (SR) or object-relative (OR) center-embedded clauses that included "short" (three-word) and "long" (seven-word) spans between the antecedent noun phrase (NP) and the "gap" where the NP is interpreted. These 13-word sentences were presented visually in a word-by-word fashion at 500 msec/word and 750 msec/word, the 500-msec rate requiring rapid information processing but the 750-msec rate requiring greater short-term memory.

Subjects were imaged on a 1.5T GE Echospeed scanner, and gradient echo echoplanar images were obtained to detect alterations in blood oxygenation (5mm slice thickness, effective TE 50msec, 64 x 40 matrix, voxel size of 3.75 x 3.75 x 5mm). The images were registered, aligned to Talairach space, smoothed with 8mm and 2.8sec Gaussian kernels, and analyzed with SPM96 using appropriate protection for multiple comparisons.

Wernicke's area supported sentence comprehension of the four main sentence types (SR short, SR long, OR short, OR long), duplicating results from an earlier 7-subject study. In this study, left middle frontal cortex and left caudate were additionally recruited during OR sentences. Broca's area was additionally recruited during OR-long sentences, again confirming earlier results.

When words were presented at a rapid rate and short-term memory demand was minimized in the short antecedent-gap sentences, Wernicke's area and caudate were recruited. This was true for both SR and OR sentences. Long antecedent-gap sentences presented slowly to maximize short-term memory load revealed Wernicke's area but no caudate activity. This too was true for both SR and OR sentences. These observations support the hypothesis that the caudate contributes to sentence processing in the form of negotiating rapid information processing, not short-term memory demand, during sentence comprehension.