Correlations between Semantic Priming, Word Recognition and Gray Matter Density

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Introduction

Semantic priming tasks provide a sensitive measure of word recognition and word meaning access. While functional MRI studies of semantic priming suggest involvement of a fronto-temporal network, regional gray matter volume associated with semantic priming in healthy older adults has not been considered. There is still some debate in the literature regarding whether semantic priming and lexical access varies with age, with reports suggesting that word recognition may slow but semantic priming may be unchanged or abnormally large. [1]. A comparison of repetition and semantic priming reveal distinct regions of activation [2], being largely fronto-temporal for semantic priming. Most neuroimaging studies of priming have employed a word pair paradigm that involves automatic spreading activation but also encourages both pre-lexical expectancy generation and postlexical semantic checking. List priming provides a means of reducing controlled processing influences as the relationship between primes and targets is less discernible to the participant. This study examines the individual differences in regional gray matter (GM) volume associated with priming in healthy older adults employing a list priming paradigm.

Methods

24 healthy controls consented to participate in the study, with a mean age of 57.6 (SD 11.4, 14 females). To test lexical access and semantic priming, participants were presented with a pseudorandomised list of words and non-words, with stimuli appearing one at a time on a computer screen and participants asked to decide as quickly and accurately as possible whether each stimulus was a real or nonsense word. The next stimulus appeared 500ms later. Within the list were occasional pairs of semantically related (brother-sister) and unrelated (wheel-carpet) items to determine the priming effect (PE). MRI scans were performed on a 4T Bruker MedSpec. A high resolution 3D T1-weighted MPRAGE sequence (TI 900ms, TR 2200ms, TE 2.99ms, resolution 1.0 x 1.0 x1.0mm) were acquired. The T13D scans were normalised, bias corrected, segmented and smoothed using the VBM toolbox in SPM5. A general linear model analysis was performed covaried with PE and a comparison of word (related and unrelated combined) and non-word reaction times (RTs) from the lexical task. Due to the significant correlations between these components and age, years of education and gender, we included these variables as nuisance regressors in both analyses. We conducted a whole brain analysis in which we adopted a voxel-wise alpha threshold of $p <$. 001, with a cluster extent threshold of 25 taking into account the non-stationary smoothness of the data.[3]

Results

Larger priming effects were associated with larger gray matter volumes bilaterally in the cerebellum as well as left angular gyrus (AG) and right postcentral gyrus. Only the right postcentral gyrus appeared to be sensitive to age, as seen by using exclusion masking ($p<0.05$). When comparing RTs for related words and non-words, greater RT differences were associated with a significant increase in gray matter volume within bilateral fusiform gyrus (FG), hippocampus (H), middle orbital gyrus, right cerebellum and left occipital cortex (area 17). See Figure 1.

When RTs for words (related and unrelated) vs non-words were contrasted, anterior and posterior areas of the right fusiform were significant, as well as the right hippocampus, right middle orbital gyrus, left fusiform and right cerebellum (crus 1). Masking this contrast to exclude for age variations ($p<0.05$) removed the areas in the right middle orbital gyrus, and left fusiform.

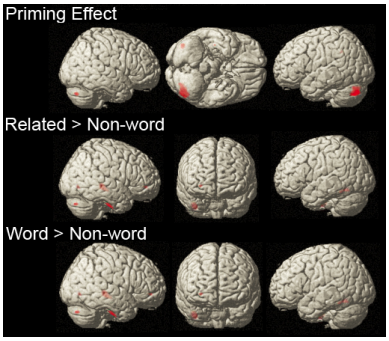

Figure 1: Areas with increased gray matter changes correlating significantly with priming effect, related and non-word targets.

Discussion

Priming effects in the present study are assumed to reflect automatic spreading activation between related words with minimal involvement of attentional mechanisms such as expectancy generation and semantic matching. Volumetric variation in the left angular gyrus was associated with priming effects, consistent with evidence of its involvement in word-meaning retrieval.[4] Although the fusiform gyrus has previously shown functional modulation with priming (showing less fMRI activation for the semantic condition)[5], there was no significant volume change in the fusiform correlating with PE in the present study. This suggests that previous findings may reflect more controlled priming mechanisms. Instead, the present study showed that volume of the fusiform is associated with general RT measures of word recognition or lexical decision making (e.g. word versus non-word). The present findings are also consistent with previous evidence of fusiform involvement in information retrieval and familiarity. [2, 6] The cerebellum has previously been linked to verbal semantic memory, and is known to be modulated by word frequency and length;[6] but could also be appearing here as it is known to be modulated with reaction times. Finally, involvement of the hippocampus and frontal middle orbital gyrus for words versus non-words suggests engagement of an attentional network during lexical decisions.

References:

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