LEFT INFERIOR FRONTAL GYRUS RELATED TO REPETITION PRIMING: LORETA IMAGING WITH 128-CHANNEL EEG AND INDIVIDUAL MRI

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Abstract

We investigated the brain substrate of repetition priming on the implicit memory taskusing low-resolution electromagnetic tomography (LORETA) with high-density 128 channel EEG and individual MRI as a realistic head model. Thirteen right-handed, healthy subjects performed a word/nonword discrimination task, in which the words and nonwords were presented visually,and some of the words appeared twice with a lag of one or five items. All of the subjects exhibited repetition priming with respect to the behavioral data, in which a faster reaction time was observed to the repeated word (old word) than to the first presentation of the word (new word). The old words elicited more positive-going potentials than the new words, beginning at 200 ms and lasting until 500 ms post-stimulus. We conducted source reconstruction using LORETA at a latency of 400 ms with the peak mean global field potentials and used statistical parametric mapping for the statistical analysis. We found that the source elicited by the old words exhibited a statistically significant current density reduction in the left inferior frontal gyrus. This is the first study to investigate the generators of repetition priming using voxel-by-voxel statistical mapping of the current density with individual MRI and high-density EEG.

A number of studies of repetition priming, have concluded that the ERPs elicited by old words are generally more positive going than those elicited by the new words (Rugg et al., 1997). It is a well-established neurophysiological index of repetition priming that repeated stimulus presentations elicit a relative decrease in neural firing, referred to as "repetition suppression". To determine the electrophysiological source locations in subjects, Low-resolution electromagnetic tomography (LORETA) (Pascual-Marqui et al., 1994) is used for solving the inverse problem. Studies using high-density EEG recording and a realistic head model are needed for the precise localization of the repetition priming generator.

The purpose of this study is to search for the localization of the generators of repetition priming on the implicit memory task. For this purpose, we utilized LORETA with a high-density 128 channel EEG acquisition system and the subjects' own 3D MRI as a realistic head model of the BEM, in an attempt to obtain a significant reduction in estimation errors. We recorded the ERP resulting from the implicit memory task, in order to evaluate repetition priming. In the lexical decision task, the words and nonwords were presented visually, and some of the words appeared twice. The subjects had to decide whether each item was a word or a nonword. We compared the ERPs produced by the old words with the ERPs produced by the new words, and analyzed the generators of repetition primingby conducting a LORETA analysis in the ERPs for each condition.

Material and methods

Subjects

Thirteen right-handed healthy subjects (males 6, females 7) were recruited.

Lexical Decision Task

The stimuli were arranged in 2 blocks of trials. Each block, included 60 words which were never repeated, 100 words which wererepeated after 1-5 intervening words, and 70 non-words which were not repeated. The subject was required to judge whether the presented item was a word or a non-word.

EEG Recordings

The subjects'EEG activities were recorded and the EEG epochs were then averaged for each subject and each stimulus-presentation condition.

Estimation of current densities using LORETA 3-D

T1-weighted spoiled gradient echo MR images for all subjects were acquired on a 1.5-T GE SIGNA Scanner. The scalp location of each electrode was determined with an Isotrak 3D-digitizer. The LORETA analysis was conducted using Curry V4.5 aftermatching the electrode locations with the individual MRI. We calculated the LORETA at the time point of the peak MGFP of the repetition priming.

Statistical parametric mapping

Spatial normalization of the current density image and statistical analysis were conducted using SPM99 software.

Results

Behavioral results

The old words elicited a significantly faster reaction time than the new words (370 ms vs. 401 ms) [F(1,11)=114.12, p=.000].

Mean amplitude differences of old and new words

Fig. 1 show the grand-average ERPs elicited by the old words and new words and topography of difference wave (ERP elicited by old words minus ERP elicited by new words) at 400 ms post-stimulus. The old words elicited more positivity than the new words. This repetition priming began at about 200 ms and lasted for about 500 ms post-stimulus.

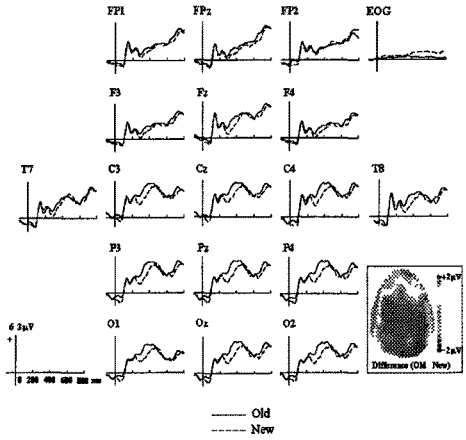

Figure 1.

Source analysis results

Fig. 2shows the statistical parametric map of t statistic (SPM{t}) of ERP generator elicited by old and new words at the latency of 400 ms. This figure registers statistic map thresholded at at $T > 3.93$ ($P < 0.001$ uncorrected) with contiguous 50-voxel extent. Sources elicited by old words are found atthe postcentral gyrus, inferior frontal gyrus, and middle frontal gyrus in the left hemisphere and atthe superior frontal gyrus and middle frontal gyrus in the right hemisphere. Sources elicited by new words extend from the inferior parietal lobule to inferior frontal gyrus and middle frontal gyrus in the left hemisphere and show on the postcentral gyrus, superior frontal gyrus, middle frontal gyrus, medial frontal gyrus in the right hemisphere.

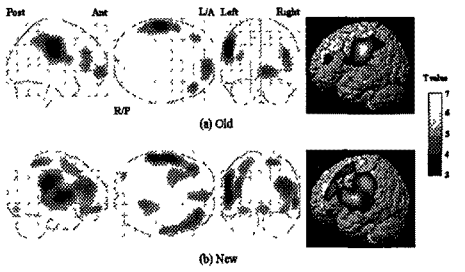

Figure 2.

The current density in the left inferior frontal gyrus in the old words condition showed a statistically significant reduction as compared to that in the new words condition with P=0.003 (uncorrected) for the voxel level. As seen

in Figure 3, the current density sources elicited by the old words showing the greatest reduction are located in the left inferior frontal gyrus (Talairach coordinates -46/2/10, BA 44).

Discussion

Based on the behavioral and ERP data, all of the subjects exhibited repetition priming in the lexical decision task. The present result is in agreement with those of previous imaging studies as regards the repetition suppression in the left inferior frontal gysus (Henson, 2003). According to the transfer-appropriate processing theory, repetition priming occurs if a given task requires the recapitulation of processing and the greater overlap of processing results in improved performance on the test (Morris et al., 1977).

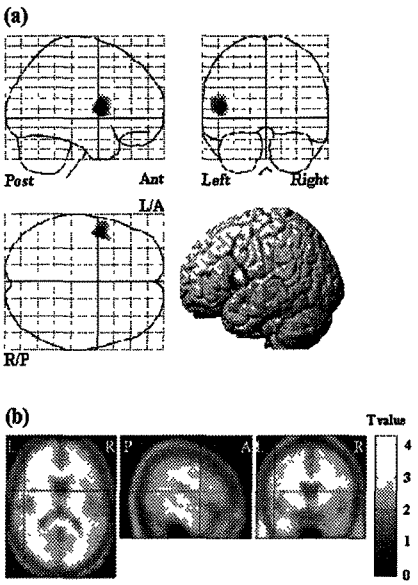

Figure 3.

This theory supports the results of the present study from the viewpoint of the greater overlap of processing between old and new words and the interpretation of the behavioral benefit of repetition priming. The benefit of past experience may induce a reduction in brain activity. Using MEGs, Fujimaki et al. (1999) suggest that repetition priming might reflect access to phonological representation via a phonologically translated code

Taken together, repetition priming may be interpreted as involving the recapitulation of processing which is facilitated by prior experience. This recapitulation of processing may be associated withthe repetition suppression observed in the left inferior frontal region, which may in turn reflect temporary modifications of existing representations in terms of phonological processing.

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