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Material-independent cerebral network of re-experiencing personal events: Evidence from two parallel fMRI experiments

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Abstract

Two parallel fMRI experiments were conducted with the aim to clarify the lateralisation issue of the cerebral network underlying autobiographical memory retrieval independently of the stimulus material and the refreshment of the memory trace. The verbal experiment required a pre-scanning interview, while the nonverbal version tested the subjects directly during the fMRI session. Both experiments were constructed using the same experimental design to eliminate methodological variables in order to render comparisons possible. We found a predominantly left-lateralised cerebral network independently of material and regardless of whether or not memory traces were reactivated prior to the scanning session. We discuss the results in the context of neuroimaging studies of autobiographical memory (AbM).

Keywords: Autobiographical memory verbal/nonverbal stimuli; Memory trace refreshment; fMRI

Generally, the neuroimaging studies of autobiographical memory (AbM) retrieval have reported a predominantly left-lateralised cerebral network [for reviews see 7,17]. In most of the studies, autobiographical information was elicited from subjects prior to the imaging experiment and cued by means of verbal stimuli during scanning [e.g., 2,18]. These two methodological issues, the time of collecting data for testing recollections and the verbal material, have been seen as naturally contributing to the predominantly left-lateralised activation pattern. Some authors addressed this point by avoiding refreshment of the memory trace prior to the fMRI experiment, reporting nonetheless, a predominantly left-lateralisation of the cerebral network while remembering past events, elicited with verbal material [e.g., 22,24]. Additionally, using nonverbal stimuli and circumventing the pre-scanning interview, Gilboa et al. [8] and Denkova et al. [6] found also a left-sided pattern of brain activations for autobiographical recollections. Interestingly, however, there are, on the one hand, a few neuroimaging studies that indicate right-lateralised or bilateral activations [e.g., 5,11]. The results have been accounted for by different factors: the emotional feature of autobiographical memories [5], retrieval of detailed memories when sufficient time is allowed [11] and the self perspective [21]. On the other hand, lesion studies have also suggested a particular contribution of right-sided lesions in AbM impairment [15].

The aim of the present study was to identify the neural correlates underlying personal recollections independently of the nature of the stimuli and the time of testing. Consequently, we undertook two parallel fMRI studies: (i) a verbal experiment requiring a pre-scanning interview and (ii) a nonverbal experiment, which did not involve testing before the fMRI session. They were constructed according to the same experimental design to eliminate some obvious methodological variables (e.g., control condition, time allowed for recollection, type of the experimental protocol) influencing the pattern of activations in order to perform a direct and as adequate as possible comparison between them.

Twenty healthy, right-handed, French native speaker subjects with no neurological impairment or psychiatric disorder, participated in the study. Ten subjects (5 females; mean age = 42.4; S.D. = 2.27; mean number of years of education = 17.8; S.D. = 3.5) took part in the *verbal* experiment, and 10 subjects (6 females; mean age = 40.6; S.D. = 5.7; mean number of years of education = 18.0; S.D. = 2.8) were recruited in the *nonverbal* study. Both groups were matched for age ($t = 0.92$; $p = 0.37$) and years of education ($t = -0.14$; $p = 0.89$). The subjects gave written informed consent and were paid according to

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the guidelines of the Alsace Ethics Committee, who approved the study.

We used in the verbal and nonverbal studies an autobiographical memory retrieval test as the experimental condition, and a semantic memory task as the control condition in line with several neuroimaging studies [12]. The conditions encompassed 10 sequences that were presented alternately; each sequence consisted of seven stimuli including five targets and two foils. The latter were used to warrant efficient attentional processes during scanning. Targets and foils in both conditions were randomly displayed on a screen for 1.24 s. The baseline between sequences consisted of a fixation cross, which was displayed for 15 s. We used a design where the retrieval time was fixed by the subjects themselves (self-paced design). Inquisit 1.33 software (Seattle, WA: Millisecond Software LLC) was used to set the timing of stimulus presentation, and to record the responses.

The verbal experiment included a pre-scanning test, 5 days prior to the fMRI session. During this test, the subjects remembered personal events by means of the modified Crovitz Test [10; French version: 19] and summarised each recollection in a two-word code to be used as a cue in the subsequent fMRI experiment. The stimuli of the autobiographical task comprised 50 pairs of words belonging to the subject and 20 pairs of words belonging to someone else. The control condition consisted of 50 semantically related pairs of words, plus 20 foils that were unrelated pairs. Immediately prior to scanning, the two tasks were explained to participants. (i) In the autobiographical condition, the subjects were instructed to remember the original autobiographical event corresponding to the coded words and to press the 'yes' switch once the recollection was built up; they were asked to press the 'no' button if the recognised code failed to trigger a recollection and if the pair of words was unknown. (ii) In the control condition, the participants were instructed to press the 'yes' button for semantically linked words and the 'no' key for unrelated items.

In the nonverbal experiment, a set of 50 photographs of relatives and friends of the participants made up the material of the experimental condition. The photos were obtained thanks to the participants' families without involvement of the participants themselves. The material of the control condition consisted of 50 photographs of famous faces (politicians, actors, musicians and sport figures). Twenty unknown faces were used as foils to control the subjects' attention in the experimental condition and the same number of unknown faces served as distractors in the control condition. Just before the fMRI session, subjects were given detailed instructions about the two tasks. (i) In the autobiographical condition, the subjects were asked to recollect a personal episode when a face of relative or friend appeared on the screen and to press the 'yes' button once the autobiographical event had been evoked. The 'no' response followed the view of unknown face or the failure to evoke a specific autobiographical episode. (ii) In the control condition, the participants were instructed to press the 'yes' button if they successfully identified the face of a famous person and the 'no' button if the face was unknown.

Whole-brain imaging was performed on a 2 T S200 whole-body MRI system (Bruker, Karlsruhe, Germany) using fMRI. Images were acquired in the axial plane with an echo planar imaging (EPI) pulse sequence using BOLD contrast with the following parameters: TE = 40 ms, TR = 2500 ms, acquisition matrix size = 64 × 64, 32 slices per volume, slice thickness = 4 mm. An anatomical MRI scan was acquired after the fMRI session for each subject.

All fMRI data were processed and analysed using the Statistical Parametric Mapping (SPM99) software (Wellcome Department of Imaging Neurosciences, London, UK). The preprocessing steps involved within-subject image realignment, spatial normalisation and spatial smoothing using a Gaussian kernel.

Firstly, an individual subject analysis was performed for each experiment separately. The haemodynamic response to each stimulus (pair of words or face presentation plus the motor response) was modelled by a canonical haemodynamic response function. We took into account only the stimuli that triggered recollections of detailed autobiographical episodes. Linear contrasts were constructed for each subject by comparing the autobiographical condition to the control condition. A random effect analysis was then performed, in which the first-level linear contrasts for each subject were submitted to a one-sample *t*-test [14]. The statistical parametrical maps were thresholded at $p < 0.001$ uncorrected. The less conservative threshold of $p < 0.01$ uncorrected was used in the medial temporal lobe (MTL). This choice was decided on the basis of the observed systematic activation of this region in the first-level linear contrasts plus our stringent *a priori* hypothesis regarding the role of the MTL. The next step, i.e., to test for possible differences between cerebral networks underlying the verbal and nonverbal experiments, was to perform a two-sample *t*-test ($p < 0.001$ uncorrected). Only clusters with a spatial extent equal to or exceeding 10 (contiguous) voxels were taken into consideration for the statistical test.

The reaction times (RTs) for the experimental conditions were 6452.74 ms (S.D. = 2823.69 ms) and 5128.36 ms (S.D. = 2504.28 ms), and for the control conditions 1465.86 ms (S.D. = 236.6 ms) and 1346.36 (S.D. = 485.17) in the verbal and nonverbal experiments, respectively.

There was no significant difference between the two experiments as regards RTs, whether these were related to the retrieval of autobiographical memories ($t = 1.10$; $p = 0.28$); or to the control condition ($t = 0.7$; $p = 0.49$). The RTs measured for experimental and control tasks were significantly different due to the temporally-extended nature inherent in the autobiographical memory retrieval process. We are aware that this difference of time could act, at least partially, as a confounding variable. In order to ensure that the general AbM cerebral pattern observed was not due to the duration difference, we undertook an additional statistical analysis, in which the autobiographical and the semantic tasks in both verbal and nonverbal experiments, were matched as closely as possible for duration. Analyses involving both full and duration matched data sets yielded virtually identical results reported elsewhere [3 for verbal; 6 for nonverbal]. Consequently, we report and discuss exclusively our full data findings.

In the verbal experiment, the retrieval of autobiographical memories was associated with a predominantly left-lateralised