# Non-fluency represented in cerebrocerebellar network: an fMRI study of overt action naming in non-fluent aphasia*

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**Introduction.** Key characteristics of non-fluent (Broca, motor) aphasia are, among others, verb finding difficulties and effortful speech output. These characteristics are related to different levels of speech production (lexical retrieval and motor execution). This study was aimed at identifying normative brain activation related to verb production in healthy individuals, as well as patterns of its reorganization depending on the locus of the linguistic deficit in patients with non-fluent aphasia.

**Method.** Participants included18 individuals with no history of neurologic impairments (mean age 44) and 4 patients with non-fluent aphasia due to left hemisphere damage: P1 (50 y.o., 8 months post-onset), P2 (50 y.o., 2 months post-onset), P3 (31 y.o., 24 months post-onset), P4 (41 y.o., 5 months post-onset). All patients were diagnosed with mild-to-moderate motor and/or dynamic aphasia and demonstrated classical non-fluent speech output. Lesion sites were diverse and included inferior frontal gyrus (the opercular part) only in P2. All participants were native speakers of Russian and were premorbidly right-handed.

An overt picture naming task was used. Participants were present with 72 black and white line drawings of actions and instructed to say aloud what the actor is doing in the picture in one verb. Action pictures were selected from the database of 400 Russian verbs and their pictures, and were balanced on critical linguistic parameters (frequency, imageability, length, argument structure). For a control condition, 32 abstract pictures were constructed by digital distortion of real drawings, so that they were not recognizable as real action pictures, but maintained the same level of visual complexity. Participants were instructed to utter a pseudo-verb 'kávaet' for the abstract pictures to simulate an articulatory response.
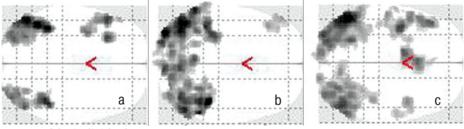
Each of the two fMRI experimental sessions consisted of 18 blocks (12 with real actions, 6 abstract pictures). A block consisted of three pictures presented for 5.5 sec each, with 0.5 sec interstimulus interval. Blood oxygen level dependent imaging (BOLD) was performed on a 1.5T Siemens Avanto scanner using gradient-echo planar sequence (TE = 50 ms, TR = 3000 ms, FOV = 25 x 25 cm, 64 x 64 matrix, voxel dimension 3 x 3 x 3 mm). A high-resolution anatomical image (T1-weighted, MPRAGE; 0.98 x 0.98 x 1 mm; TE/TR 3/1900 ms) was also acquired. FMRI data analysis was performed in SPM8.

Due to poor quality of oral response recording in the scanner, participants with aphasia underwent a naming testing out of the scanner the following day (a preliminary study confirmed that patients with aphasia show no learning effect in naming identical action pictures on two consecutive days). The same action pictures were presented with the same timing parameters, but in a different order. Participants' responses were quantitatively and qualitatively analyzed.

**Results.** In healthy Russian speakers, action naming relative to the baseline condition (uttering a pseudo-verb in response to an abstract picture) elicited extra brain activation in occipital regions bilaterally, left inferior temporal gyrus and, critically, the triangular part of inferior frontal gyrus (Fig. 1a).

Patients with aphasia showed brain activations in bilateral occipital regions, as well as in inferior frontal gyrus, similarly to healthy individuals. The additional activation found in patients, but not in healthy individuals, was dependent on their quantitative scores and type of errors during the naming testing out of the scanner. P1 and P2 named correctly 68% and 65% of actions, correspondingly. Most of the incorrectly named items were non-dominant, but synonymous nominations ('lifting' – 'pulling'). Thus, P1 and P2's ability to name actions might be considered relatively spared. In contrast, P3 and P4 were only 32% and 26% correct, and the errors were mostly non-responses and semantic paraphasias ('searching' – 'palpating'). The same patients' grouping was observed in fMRI results. P1 and P2 activated right cerebellum regions for action naming more than in the baseline condition (Fig. 1b for P1). For the same contrast, P3 and P4 showed wide-spread frontal left hemisphere activation (supplementary motor area, precentral gyrus), as well as additional right hemisphere activation (supplementary motor area, precentral gyrus, inferior and middle temporal gyrus in P3; middle frontal gyrus in P4), as illustrated in Fig 1 c for P3.



Healthy individuals    High-score patients    Low-score patients

*Fig. 1. SPM-glass brain depiction of the activation pattern for action naming compared to the baseline condition*

**Discussion.** Brain activation pattern found in healthy individuals supports critical involvement of inferior frontal gyrus in verb production. Extra activation in response to action pictures relative to abstract pictures in bilateral occipital regions and left inferior temporal gyrus, which are parts of the ventral visual stream, reflects the necessity to recognize human actors and tools in action pictures.

The observed two different patterns of brain activation in patients with non-fluent aphasia suggests that P1 and P2, on one hand, and P3 and P4, on the other hand, have

two different locus of linguistic impairment and use distinct brain mechanisms to overcome their deficits. Verb retrieval per se was relatively spared in P1 and P2, as follows from their naming scores. It was motor execution of the word that caused difficulties in them. The effort to overcome those difficulties resulted in specific activation in the right cerebellum, which is known to be a regulator of speech temporal sequencing. In contrast, P3 and P4 had intrinsic linguistic difficulties with verb finding and used wide-spread bilateral frontotemporal network to overcome them.

Thus, in addition to the identification of brain substrate involved in normative verb production, the present study showed how different loci of linguistic deficits within the same aphasia syndrome are represented in distinct cerebrocerebellar networks.

## Lobar localization information in epilepsy patients: comparison between long-term video-EEG monitoring and MEG

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**Purpose.** Magnetoencephalography (MEG) and magnetic source imaging (MSI) are techniques that have been increasingly used for preoperative localization of epileptic foci. To help elucidate the value of MEG, we assessed the results of whole-head MEG versus video-EEG (vEEG) in the case management of patients undergoing epilepsy surgery.

**Method.** We studied 19 patients with suspected focal epilepsy who underwent interictal and ictal vEEG and, subsequently, interictal and ictal MEG. Out of 19 patients studied 14 were with suspected neocortical epilepsy, 5 with with mesial temporal lobe epilepsy. Nine patients underwent surgical resection of suspected epileptogenic zone and seven of them – invasive electrocorticography (ECoG). The results of MSI were classified to define epileptogenic foci according to the clastering of interictal and ictal spikes recorded during a 4-hour recording session. The data were analyzed to determine to what extent the results of MSI correlated with vEEG determined irritative zones.

**Results.** In 4 of 19 cases MSI – determined localization regionally correlated with vEEG data (that is, showed the same lobe). In fifteen patients MSI showed 32 additional epileptogenic foci that interictal vEEG was unable to identified. These undetected sources were localized mainly in the frontal and temporal lobes (70%), and at the lobar surface level - at the medial and the basal aspects of cerebral lobes (70%). In six cases, MSI