

PATTERNS OF BRAIN ACTIVATION PREDICTING GREATER LANGUAGE IMPROVEMENT IN NON-FLUENT APHASIA

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Background

- Aphasia is a complex disorder of developed language ability (production and comprehension of oral and written language), encompassing disturbance of phonemic, morphological, lexical-semantic and syntactic levels of language while articulation, primary hearing and vision are intact (Luria, 2000; Khomskay, 2003; Hallowell & Chapey, 2008)
- Non-fluent aphasia is characterized by major disturbance in speech production with sparse, halting speech, words often misarticulated, reducing fluency of speech in all tasks, disturbances in speech planning and affecting elements of language such as grammatical words, morphological endings and production of complex syntactic structures without severe disturbance of auditory comprehension (Caplan D., 2003).
- A lot remains unknown about how language is processed in the damaged brain and what the exact relationship between cerebral reorganization and language recovery is (Thompson & den Ouden, 2008).

Aim of the study: to investigate if specific brain activation patterns associated with language performance are indicative of the degree of overall language improvement.

Methods

Participants.

Right-handed neurologically healthy subjects (n = 16; mean age: 35,7, range: 25-59; SD=8,05, female - 13) and individuals with moderate chronic non-fluent aphasia following a left hemisphere CVA (n = 4; mean age: 57,5, range: 46-70; SD=10,6). All participants were native speakers of Russian. The MRI investigation showed that participants with aphasia had lesions in the left fronto-parietal areas.

Tasks (all materials were presented in Russian):

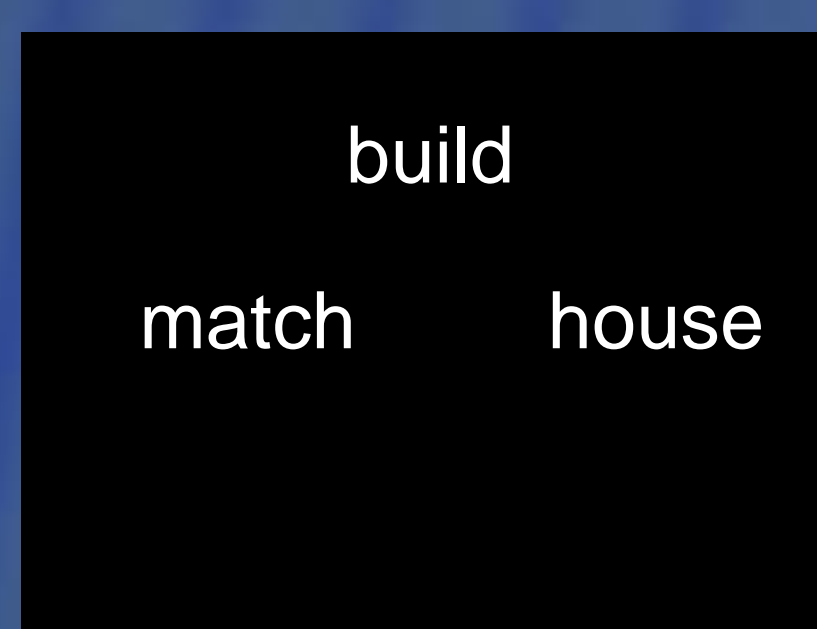
I. fMRI task (was conducted at the middle of a 45-day long intensive rehabilitation course):

1. Experimental condition.

Choose a correct object to the verb above (36 blocks + 2 training block, 114 verbs were balanced on critical psycholinguistic parameters (frequency, imageability, length, argument structure)).

2. Control (baseline) condition.

Choose a sequences of symbols that is identical to the one above (12 blocks + 2 training block, 42 sequences of symbols typed in Wingdings). Each of the two block types were presented for 18 sec, three pictures in each block, each picture lasting for 5,5 sec, with 0,5 sec interstimulus interval.



Blood oxygen level dependent imaging (BOLD) was performed on a MAGNETOM Avanto 1,5T (Siemens) scanner using gradient-echo planar sequence (TE= 50 ms, TR= 3000 ms, FOV = 25 x 25 cm, 64x64 matrix, voxel dimension 3x3x3 mm). A high-resolution anatomical image was also acquired (T1-weighted, MPRAGE; 0,98 x 0,98 x 1 mm; TE/TR 3/1900 ms). fMRI data analysis was performed in SPM8 (p < 0,001, the threshold significance level of clusters p(FWE) < 0,001). Individual presentations were performed in MRICroN.

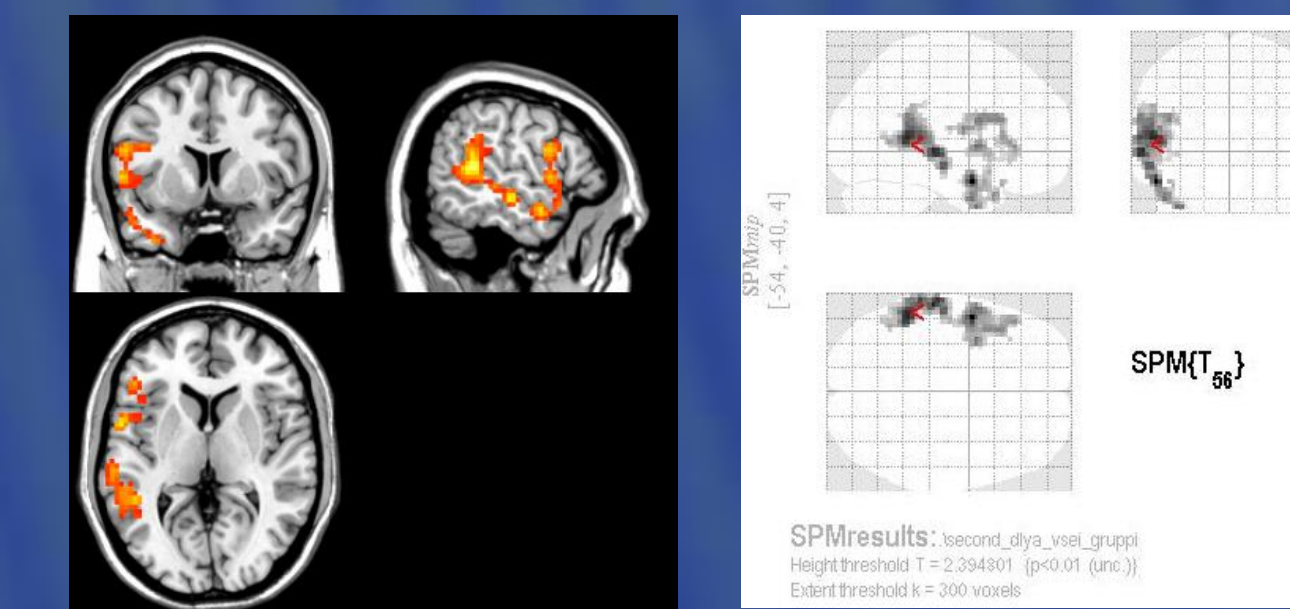
II. ASA (the Assessment of Speech in Aphasia (Tsvetkova, Ahutina, & Pulaeva, 1981)

(was measured twice: pre- and post- the rehabilitation course).

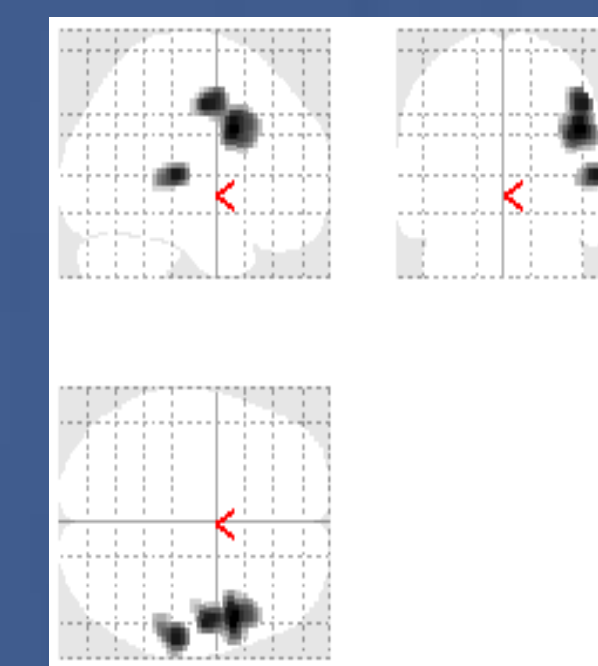
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| 1. The comprehension part of the test includes: | 2. The expressive part of the test includes: |
| a) Comprehension of questions about activities of daily routine; | a) Responding to questions about activities of daily routine; |
| b) Comprehension of nouns; | b) Object naming; |
| c) Comprehension of verbs; | c) Action naming; |
| d) Comprehension of sentences; | d) Sentence construction; |
| e) Follow verbal instructions. | e) Picture description. |

Results

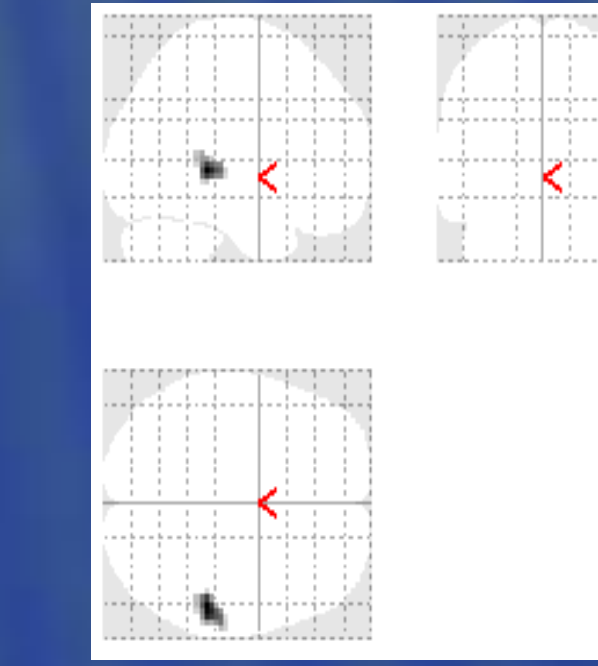
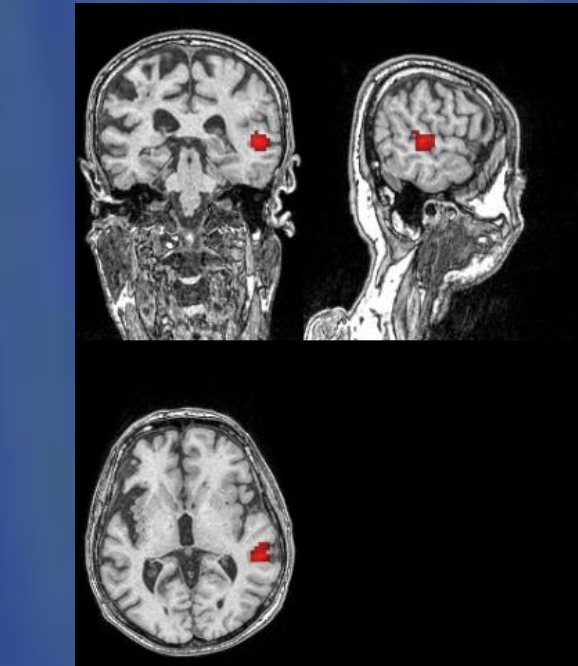
In healthy participants, matching nouns to verbs as compared to the baseline condition elicited activation in the frontal gyrus [-45,35,-8], superior and middle temporal [-57,5,-17] areas of the left hemisphere.



Patients with minor improvement

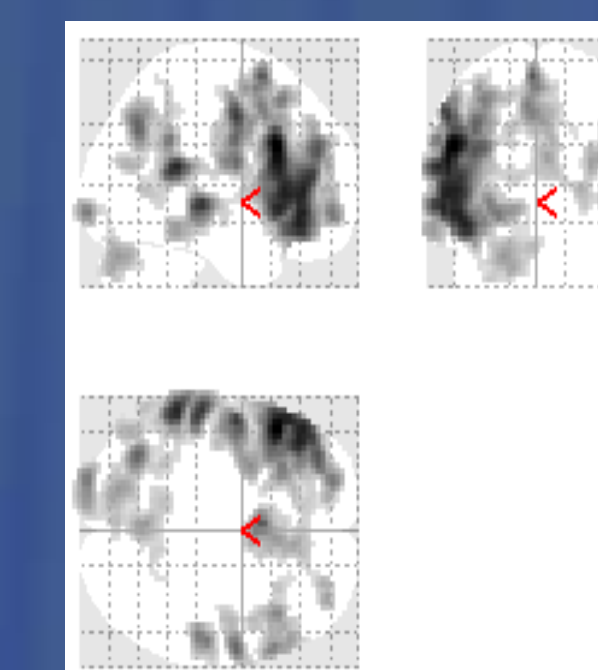
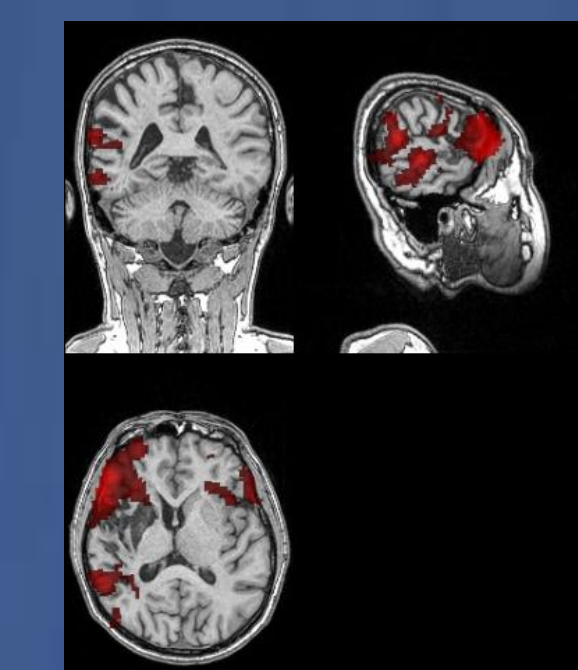


46 y.o., female, 4 years post stroke. fMRI: activation in the right superior temporal, right inferior and middle frontal gyri.

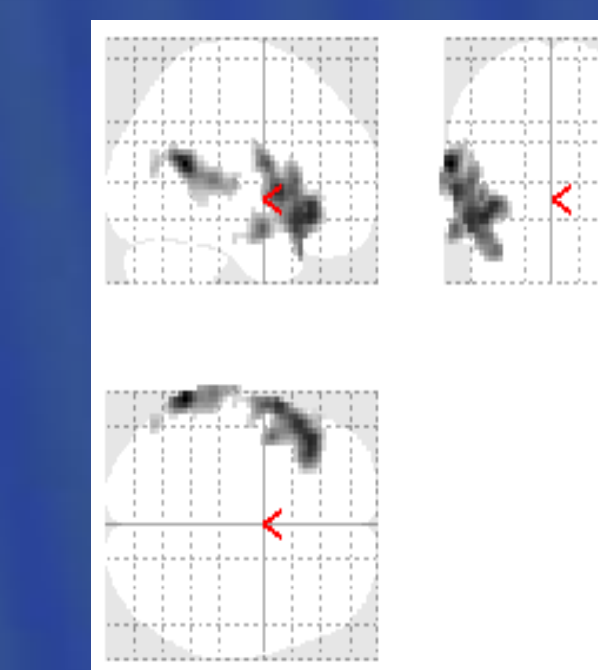
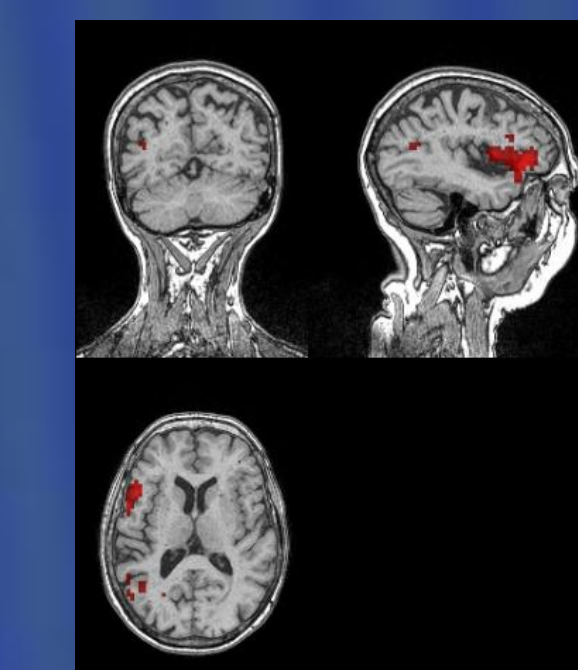


62 y.o., male, 13 months post stroke. fMRI: activation in the right superior temporal gyrus.

Patients with significant improvement



52 y.o., male, 5 months post stroke. fMRI: activation in the left inferior and middle frontal perilesional areas, left superior and middle temporal gyri, right inferior frontal gyrus, right temporal area, precentral gyri and parietal areas bilaterally.



70 y.o., female, 7 months post stroke. fMRI: activation in the left inferior and middle frontal perilesional areas, left superior and middle temporal gyri.

Discussion

- For neurologically healthy participants activation was found in the left triangular part of the inferior frontal gyrus, that is a classical speech area for expressive speech, production of the right order of words and their reasonable combinations i.e. syntax (Caplan D., 2003) and extensive activation in the superior and middle temporal areas that are involved in verbs and action knowledge representation. (Dronkers et al. 2001).
- Participants with significant improvement showed patterns of activation similar to the healthy controls in the left inferior and middle frontal perilesional areas, left superior and middle temporal gyri. It is possible that extensive re-recruitment of the left posterior frontal and temporal areas during language rehabilitation is indicative of overall significant improvement.
- Participants with minor improvement showed brain activation patterns in the right temporal area and one of them also demonstrated additional activation in the right inferior and middle frontal gyri. It is possible that recruitment of just the right hemisphere areas leads to less efficient language processing and thus is associated with less improvement.
- These findings are in line with previous studies that demonstrated additional left hemisphere activation associated with better language performance in aphasia while additional recruitment of the right hemisphere usually reflected less efficient language processing in the chronic recovery phase (Fridriksson et al., 2009, 2010; Price & Crinion, 2005).
- Obtained findings need to be corroborated by further research, with future studies including more detailed measures of language recovery along with tracking brain activation over time.