Functional Neuroanatomy of Semantic Aphasia

Yulia Akinina[1, 2], Olga Dragoy[1], Nina Dronkers[3]
[1]National Research University Higher School of Economics, Russia; [2]University of Groningen, The Netherlands; [3]VA Northern California Health Care System, University of California, Davis, USA

Background & Aim

Semantic aphasia syndrome is:

- A deficit in comprehension of "logical-grammatical constructions": instrumental, prepositional, comparative etc.; with spared speech fluency, auditory comprehension, reading and repetition of single words or simple phrases.
- Associated with lesions in left temporal-parietal-occipital (TPO) cortical regions (BA 18, 19, 37 and 39).
- Conceptualized as a disorder of spatial nature related to inability of integration of linguistically-mediated elements into a unified representation (Luria 1947/1970).

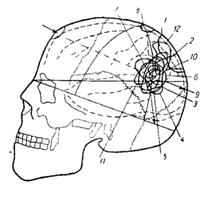

Fig 1. Lesion overlay of 12 patients with semantic aphasia (Luria, 1947).

We studied 10 contemporary patients with semantic aphasia and here analyze both their neuropsychological profiles and lesion neuroimaging data including the extent of white matter involvement, data that were not available to Luria at the time of his historical reports.

Method

Participants: ten native speakers of Russian, aphasic due to stroke, premorbidly right-handed (except one forced right-handed); mean age (range): 57 years (33-71); education: 13 years (8-15), months post-onset: 22 (2-61); seven females.

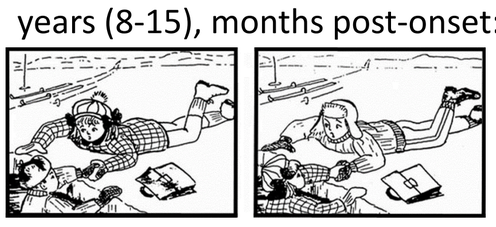

Fig 2. Picture stimuli for the probe "*The boy-ACC rescued the girl-NOM*" (logical-grammatical constructions) (Tsvetkova et al., 1981)

Neuropsychological assessment: logical-grammatical constructions, metaphors, writing, reading, spatial constructional praxis, visual spatial gnosis, somatospatial praxis, calculations.

"Luria's list": In Online Brain Atlas Reconciliation Tool (Bohland et al., 2009), left BA 18, 19, 37 and 39 were selected in the Talairach Daemon cell-level Atlas and laid over the AAL map; an overlap of more than 5% was included.

NEUROIMAGING: the lesions were manually delineated and normalized to MNI152 1 mm template. Misalignments between the lesions in the native and in normalized space were manually corrected in the normalized file.

Grey matter involvement: overlaying individual lesion masks to AAL template in MRICron.

White matter involvement: quantifying the probability of tracts being disconnected by overlaying lesion masks onto tract masks in Tractotron software (Thiebaut de Schotten et al., 2014).

Results

NEUROIMAGING

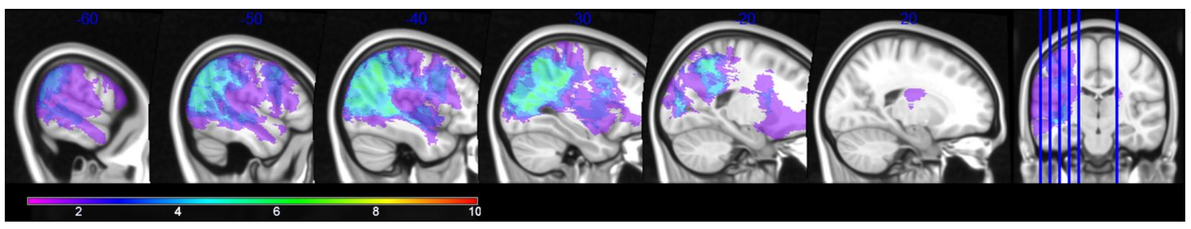

Fig 3. Lesion overlay of ten patients with semantic aphasia.

- **Grey matter**: six TPO and four non-TPO patients:

Luria' list:	Patients									
	1	2	3	4	5	6	7	8	9	10
Angular gyrus	99.0	73.9	99.3	100	15.2		4.2	66.6		
Calcarine sulcus		7.8	0.7							
Cuneus	0.9	21.7	0.7							
Fusiform gyrus		3.2								
Lingual gyrus		3.1								
Inferior occipital gyrus	7.5	20.8	15.8		0.5			24.5		
Middle occipital gyrus	57.4	66.9	74.5	49.9	43.5			38.5		
Superior occipital gyrus	2.0	48.8	9.0	3.5	25.1					
Inferior parietal lobule	92.8	38.3	88.6	63.4	19.6		0.8	18.3		
Inferior temporal gyrus	7.1	5.6	1.0			2.6		0.9		
Middle temporal gyrus	66.2	22.1	18.6	14.3	1.2	32.6	3.5	5.4	0.5	

Table 1. The percentage of the voxels in regions from Luria's list (LH for patients 1-9, RH for patient 10) intersecting with the lesion mask.

White matter: k-means cluster analysis (three clusters) of the probability of disconnection of the individual tracts. Cluster 3 with the highest mean probability (=0.92) of disconnection contained the arcuate fasciculus, long and posterior segments; corpus callosum, inferior fronto-occipital fasciculus, inferior longitudinal fasciculus, optic radiations and superior longitudinal fasciculus, II and III.

NEUROPSYCHOLOGICAL ASSESSMENT

- All 10 patients were impaired in the comprehension of logical-grammatical constructions and spatial constructional praxis
- The majority of patients had compromised writing (N = 7), metaphor appreciation (N = 6), visual spatial gnosis (N = 7), and calculation (N = 7), and a few patients showed problems in somatospatial praxis (N = 5) and reading (N = 4).
- The errors made by patients suggested the spatial nature of the underlying disorder, e.g.: spatial discoordination and transpositions, left-right confusion, and an inability to rely on holistic reading and writing strategies.

Tracts from Cluster 3	Patients									
	1	2	3	4	5	6	7	8	9	10
Arcuate fasc., long	1.00	1.00	1.00	1.00	1.00	0.94	1.00	0.94	1.00	0.64
Arcuate fasc., posterior	1.00	1.00	1.00	1.00	0.92	1.00	1.00	0.98	0.46	
Corpus callosum	1.00	1.00	1.00	1.00	1.00	0.98	1.00	1.00	1.00	0.96
Inf. fronto-occipital fasc.	1.00	1.00	1.00	1.00	0.94	1.00	1.00	0.98	1.00	
Inf. longitudinal fasc.	1.00	1.00	1.00	1.00	0.96	1.00	1.00	1.00	1.00	
Optic radiations	1.00	1.00	1.00	1.00	0.99	0.97	1.00	1.00	0.90	
Sup. longitudinal fasc., II	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1.00	0.94	0.54
Sup. longitudinal fasc., III	1.00	1.00	1.00	1.00	1.00	0.98	1.00	0.96	1.00	0.91

Table 2. Probability of white matter pathway disconnection for each patient in tracts from Cluster 3

Discussion

- A large number of patients had left TPO lesions and thus followed Luria's predictions.
- The tracts that connect to the parietal areas – the arcuate fasciculus (long and posterior segments), the inferior fronto-occipital fasciculus, the inferior longitudinal fasciculus, the superior longitudinal fasciculus II and III, and the corpus callosum – were probably implicated in the linguistic and non-linguistic deficits of patients with semantic aphasia.
- White matter damage might play an important role in the syndrome (see non-prototypical cases).