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Sekce pro funkční mapování mozku

České společnosti pro klinickou neurofyziologii ČLS JEP

MAFIL

Movement artifacts in fMRI

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Educational course: NeuroImaging

Mapping the function and structure of brain

Brno, 14.-16.11.2016

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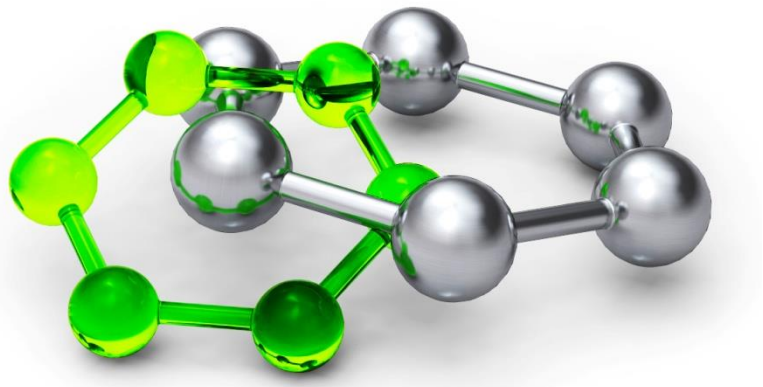


Movement artifacts in fMRI

- Most important artifact in fMRI data
- As a result of movement of subject's head during acquisition
  - Translation and rotation of scans – it is possible to correct using some realignment procedure
  - Artificial changes in BOLD signal – it is not easy to correct it completely

- Movement within one scan (one TR)
  - *Phase-encoded* artifact – distortion in phase encoding axis
- Movement between consecutive scans

Movement artifacts in fMRI

- Movement between consecutive scans
  - Susceptibility artifact
    - Interaction between inhomogeneities of outer magnetic field and inhomogeneities at the border of tissues with different susceptibilities
    - Both distortion of geometry and signal amplitude
  - Spin-history artifact
    - Casued by movement along main axis (z) of static magnetic field
    - Distortion of signal amplitude in regions with T1 >> TR due to incomplete longitudinal relaxation
    - Signal measured from different slice than the excited one

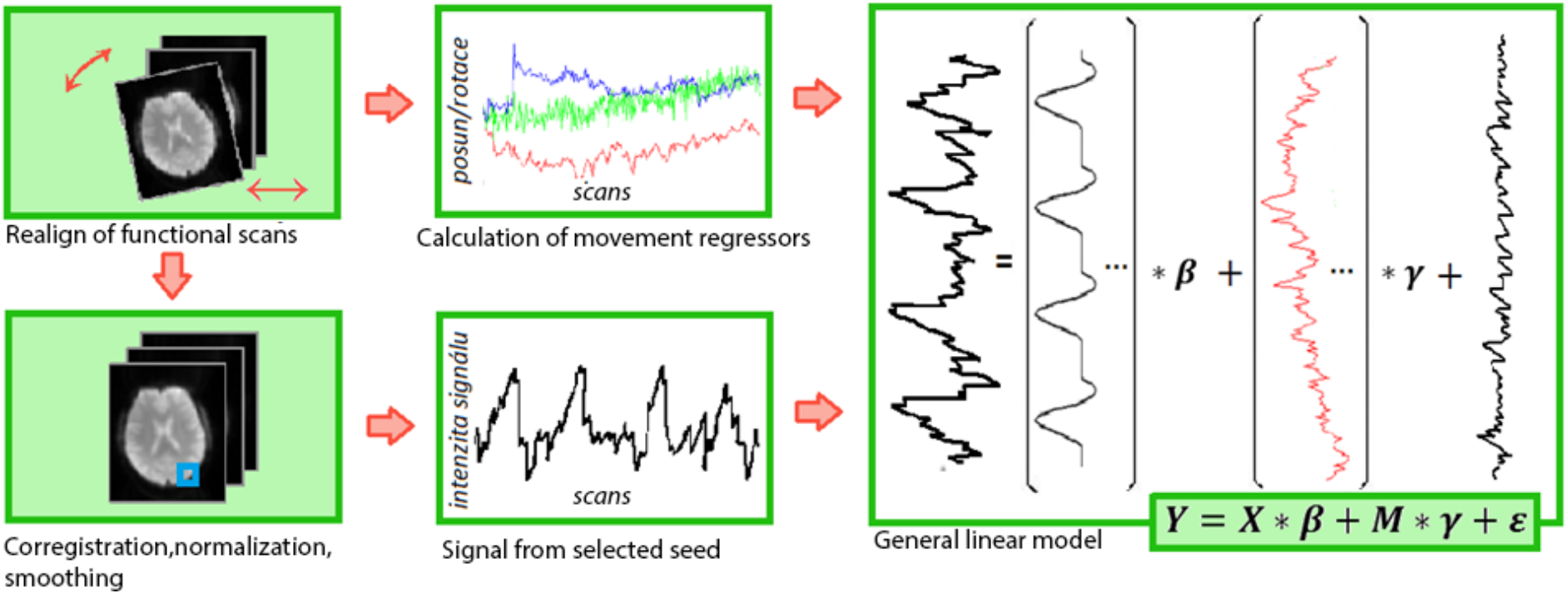
Mapping of movement artifacts

- Consideration: movement artifacts will be localized into the same regions across subjects
- Use of movement parameters as some global parameters describing movement of subject's head during acquisition

- Realignment of scans
  - Rigid body transformatin with 6 parameters
    - 3 for translation in main axes
    - 3 for rotation along main axes
  - Only correct the position of images – not change distortion of BOLD signal

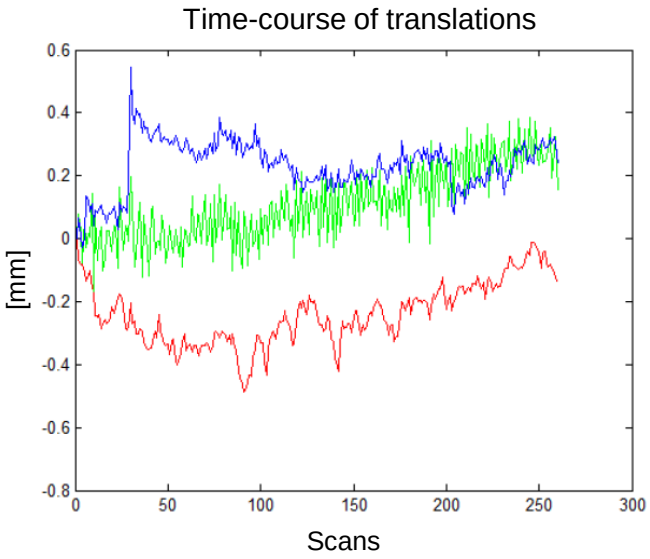
Mapping of movement artifacts

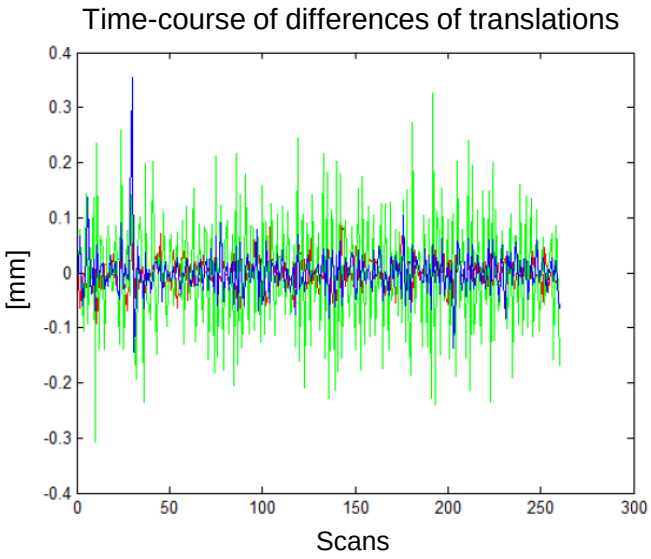
- Movement parameters in GLM
  - Time-courses of translations and rotations are used as regressors in GLM



Mapping of movement artifacts

- 6 movement parameters obtained from realign procedure
- Calculation of 24 movement parameters
  - 1. difference – effect of memory, acceleration
  - Squares of movement params. – non linear relationsip





Mapping of movement artifacts

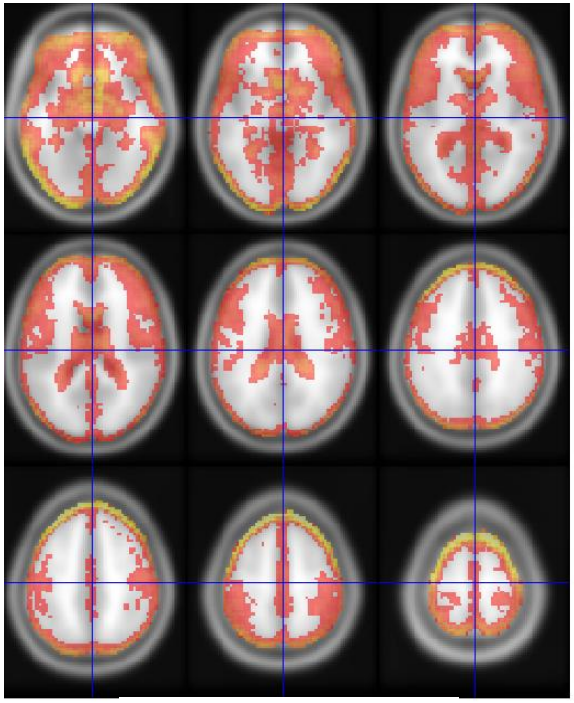
- Power maps
  - Calculated as ratio between energy (variability) of signal explained by movement regessors and total energy (variability) of measured signal
  - Provide percent of variability explained by movement in each voxel

$$sig_{movement} = \sum_{reg=1}^{24} X(reg) \cdot \beta \cdot c$$

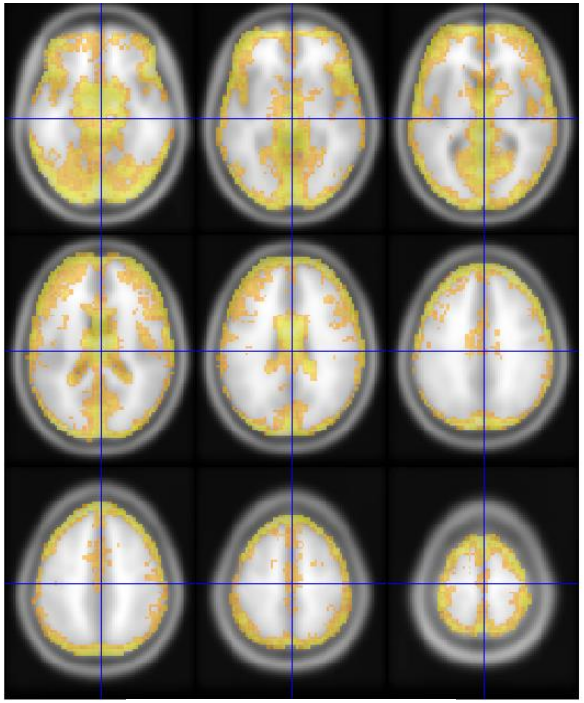
$$energy = \frac{1}{n} \sum_{i=1}^{n} (x_i - E(x))^2$$

$$percent\_of\_power = \frac{energy_{movement}}{energy_{total}} \cdot 100$$

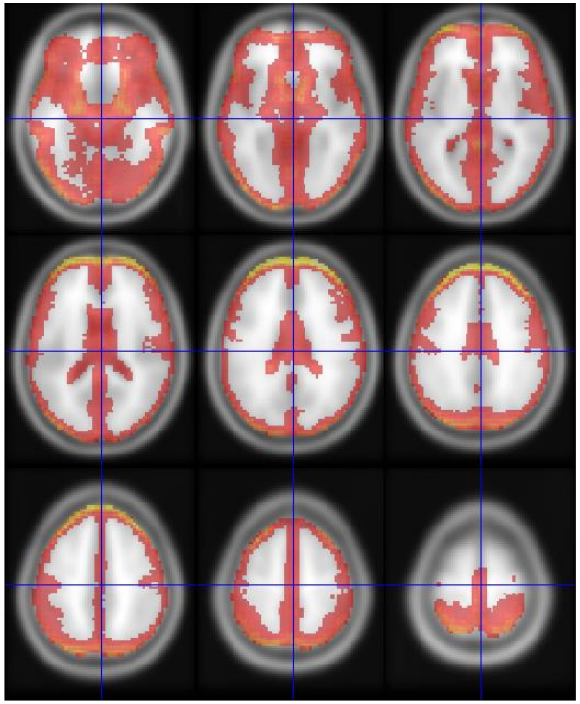
Mapping of movement artifacts



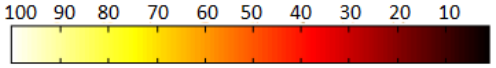
VSMT, threshold 25%



VFTv, threshold 30%

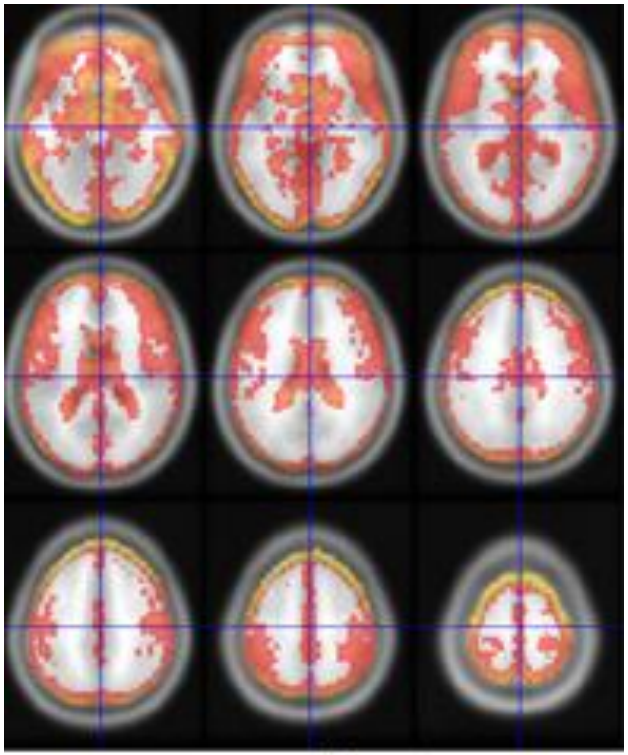


VOBd, threshold 13%

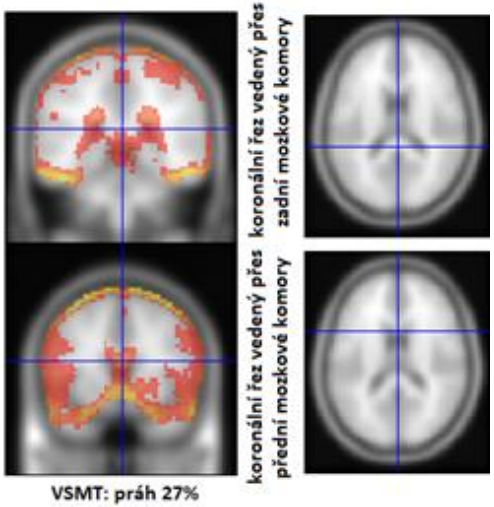


Mapping of movement artifacts

- Typical regions affected by movement artifacts in fMRI
  - Borders of brain
  - CSF compartmnets and corpus calosum
  - Longitudinal fissure of cerebum



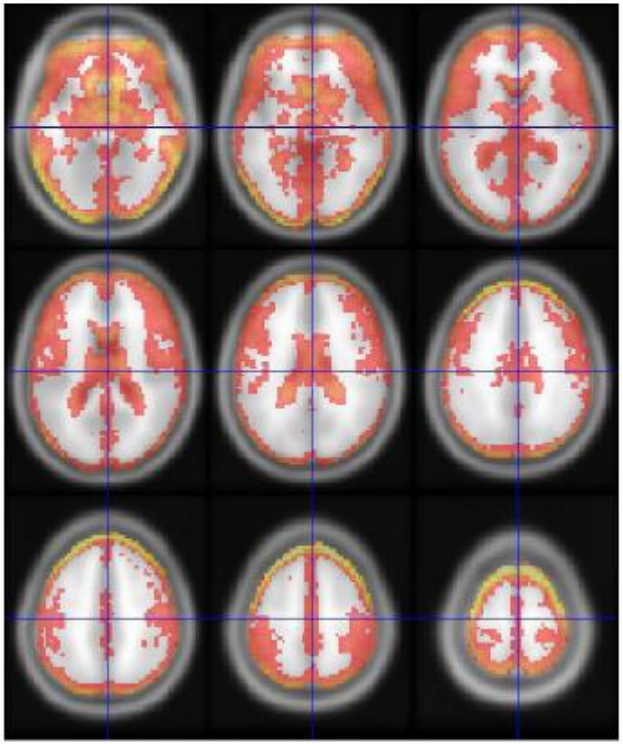
VSMT, threshold 25%



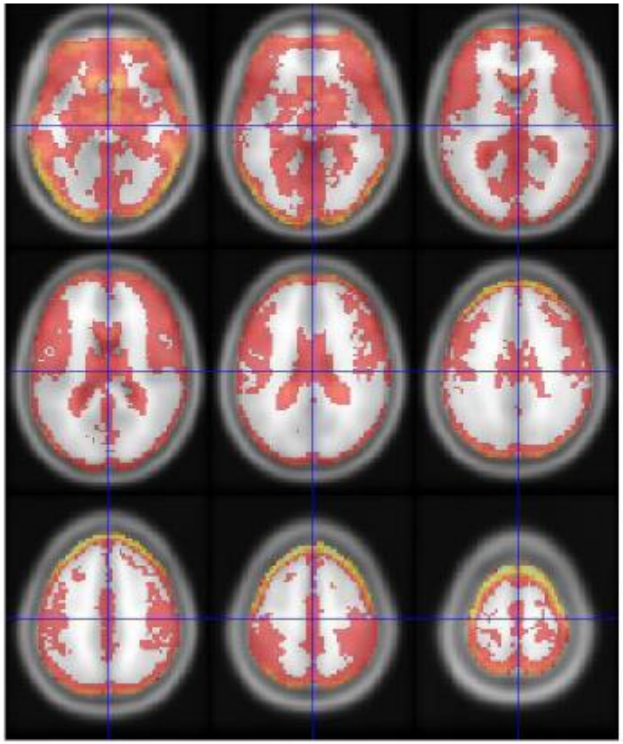
VSMT: práh 27%

Mapping of movement artifacts

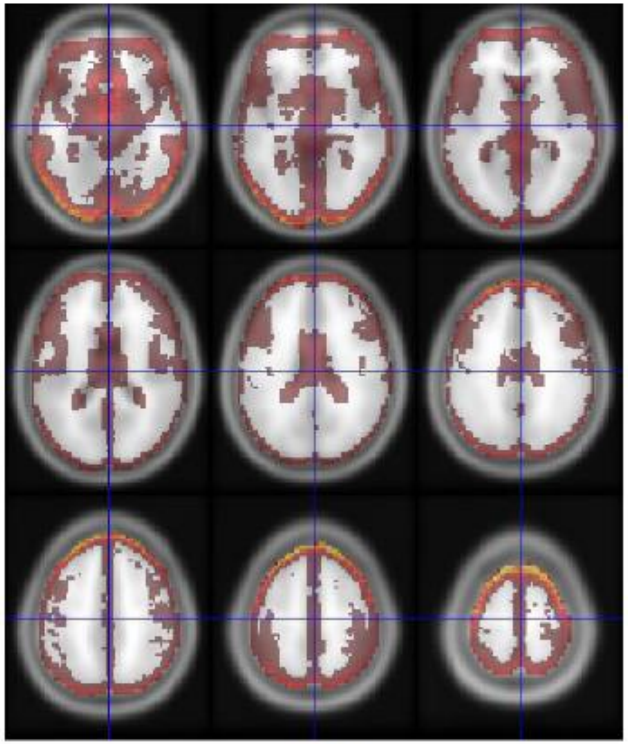
- Various number of movement regressors



Threshold 25%
24 movement regressors



Threshold 18%
12 movement regressors



Threshold 3%
6 movement regressors

Mapping of movement artifacts

- Effect of various movement parameters

	x_translation	y_translation	z_translation	x_rotation	y_rotation	z_rotation
1. differences						
squares						
squares of 1. differences						

VOBd2	SemDec	VSMT	Null300	VFTv
TR = 1,66	TR = 1,85	TR = 2,05	TR = 3	TR = 4,52
ns = 256	ns = 230	ns = 260	ns = 300	ns = 71

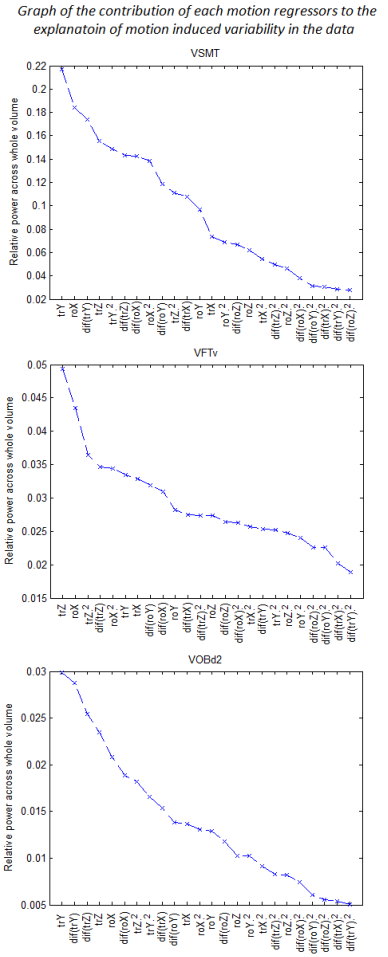


Figure 3: Contribution of each motion regressors to the explanation of motion induced variability in the data. Three different datasets were included into the evaluation (visual-memory task – VSMT, verbal-fluency task – VFTv, visual oddball task VOBd2). Value of relative power across whole volume was calculated as a sum of relative power values across all voxels divided by number of voxels (in whole cuboid volume)

How to suppress movement artifacts?

- Using regressors in GLM

- Prospective motion correction
- Spike regression (Satterthwaite et al., 2013a)
- Motion scrubbing (Power et al., 2012)
- aCompCor (Behzadi et al., 2007; Muschelli et al., 2014)
- Using edge voxel information (Patriat et al., 2015)
- Motion Simulation method (Patriat et al.,2016)

ICA based approaches

- ICA-AROMA (Pruim et al, 2015)
  - Robust approach, fully autmatic
  - Classification of ICA components
    - Contain of high-frequency components
    - Correlation with movement params
    - According to border parts
    - According to CSF
  - Subsequently, artificial components are suppressed from data
- ICA-FIX (Griffanti et al., 2014; Salimi-Khorshidi et al., 2014)


No, sir.
I do not like to "move it, move it."

Thank you for your attention

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