Institute for Cognitive Neuroscience

Master's Programme
'Cognitive Science and Technology:
From Neuron to Cognition'

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Steady-state visual evoked fields study of contrast gain control in VSS

By Naumova Sofiya
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Introduction:
Research relevance

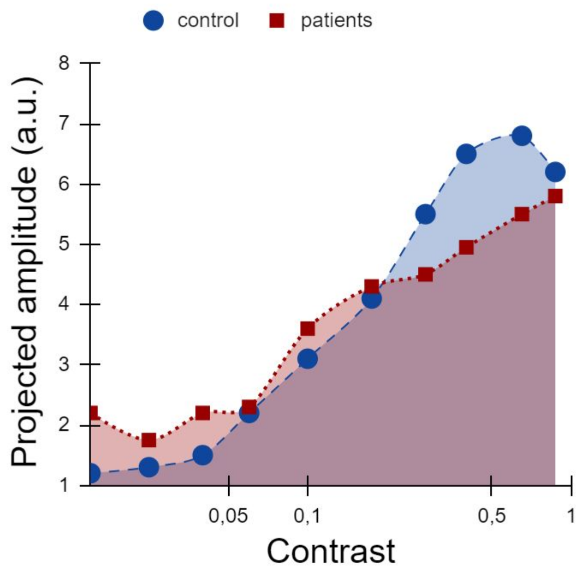
- Visual Snow Syndrome (VSS) occurs in 2% of people (Kondziella, 2020);
- Increased excitability of the visual cortex is considered the most likely cause of the development of visual snow syndrome (Ghannam et al., 2017)

Illustration of symptoms of VSS
https://tenor.com/

Introduction:
Contrast gain control

- Contrast gain control is an increase in the number of excited neurons in response to increase in stimulus contrast.

- To assess contrast gain control, the method of steady-state visual evoked potentials or magnetic fields is used.



Mean contrast response function for control group and subjects with idiopathic generalized epilepsy. Modified from Won et al., 2017.
DOI: 10.1016/j.clinph.2016.12.008

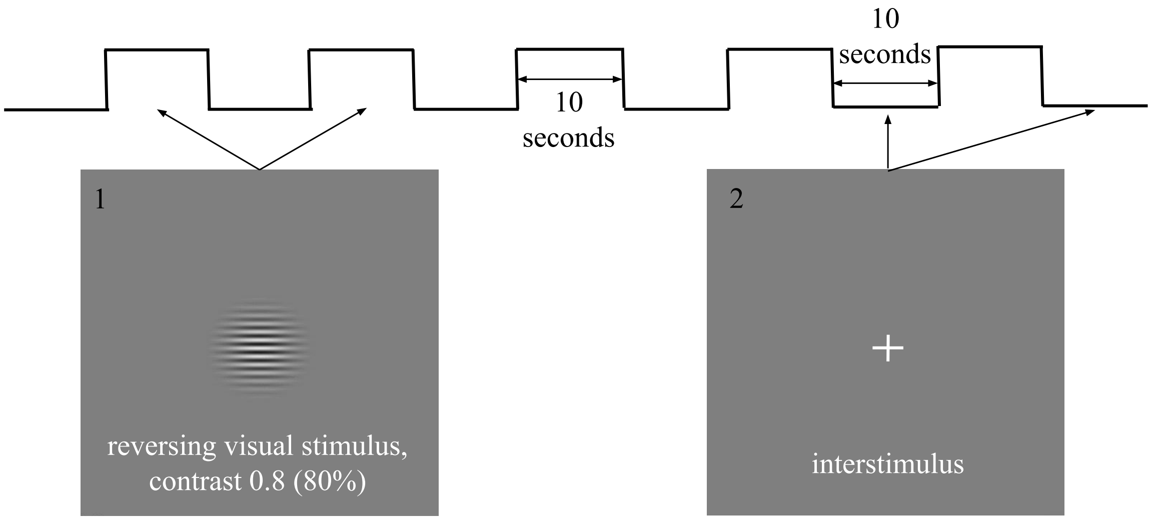
Research questions

Aim: studying the balance of excitation and inhibition processes in the visual cortex in people with visual snow syndrome using magnetoencephalography.

Hypothesis: Both contrast gain control, measured in the visual cortex using steady-state visual evoked magnetic fields, and the level of visual discomfort (Conlon, 1999) are hypothesized to deviate from normal in individuals with VSS toward a predominance of excitatory processes in the visual cortex.

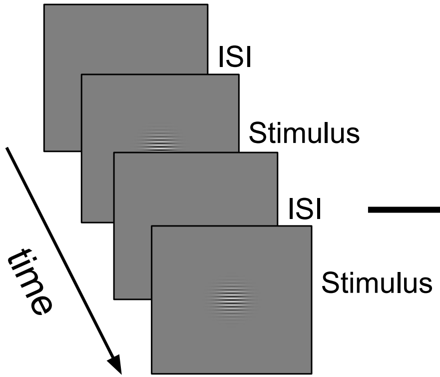
Experimental paradigm

- black and white horizontal reversing gratings (1) of five contrasts (0.05, 0.1, 0.2, 0.4, 0.8);
- five 10-second blocks of stimulus presentation of one of five contrasts;
- 10-second intervals between blocks with presentation of a white fixation cross on a gray background (2)



Sample and research methods

The study includes 49 subjects with normal or corrected-to-normal vision (21 subj. with VSS and 28 control subj.)



Contrast levels: 0.05, 0.1, 0.2, 0.4, 0.8

→ MEG raw data → (Maxfiltering, ICA, filtering, epoching, cleaning) → Artifact-free epochs → (Spectral analysis) → Signal power for each contrast → (Fitting) → Contrast gain control coefficients s

Preliminary results. Spectral analysis

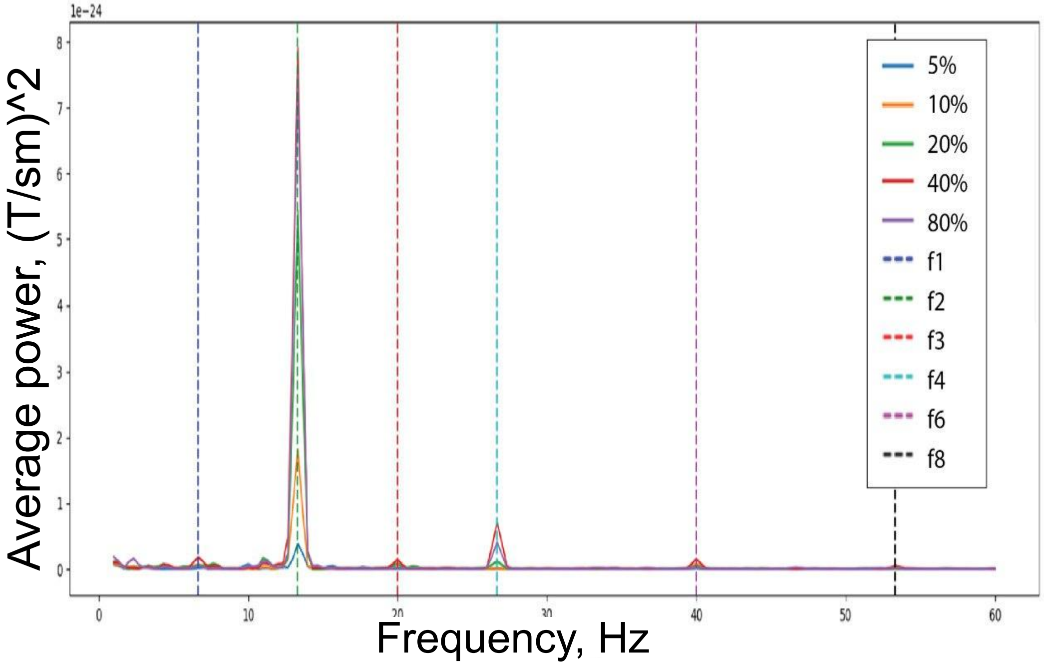


Fig.1. Power spectrum caused by pattern reversal with a change of 6.(6) Hz. Spectrum of one subject, gradiometer with maximum power. C1, C2, C3, C4, C5 – contrasts stimulate 5%, 10%, 20%, 40%, 80%, respectively. f1, f2, f3, f4, f6, f8 – reversal frequency (f1) and harmonics of the received signal.

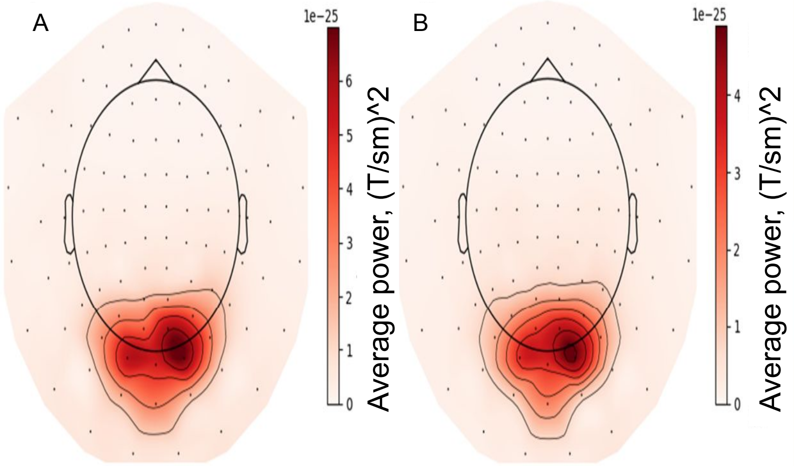


Fig.2. Group distributions of power summed at the stimulation frequency and its harmonics

Preliminary results. Embedding a Contrast Gain Control Model

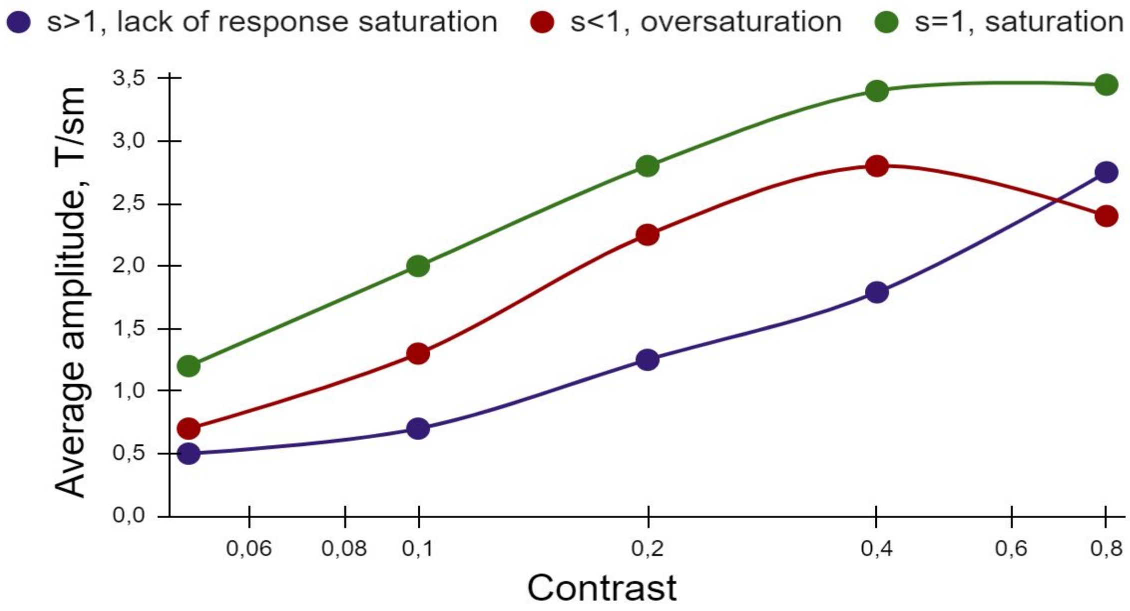


Fig.3. Examples of individual contrast response functions, which are characterized by saturation, oversaturation and non-saturation of the response at high contrast levels.

$$R = R_{max} \frac{c^2}{v^{2s} + c^{2s}} + b$$

Standard stimulus response model:
R - response magnitude,
c - stimulus contrast,
Rmax - maximum response,
b - baseline,
v - half-saturation constant,
s - parameter characterizing the degree of saturation

Preliminary results. Embedding a Contrast Gain Control Model

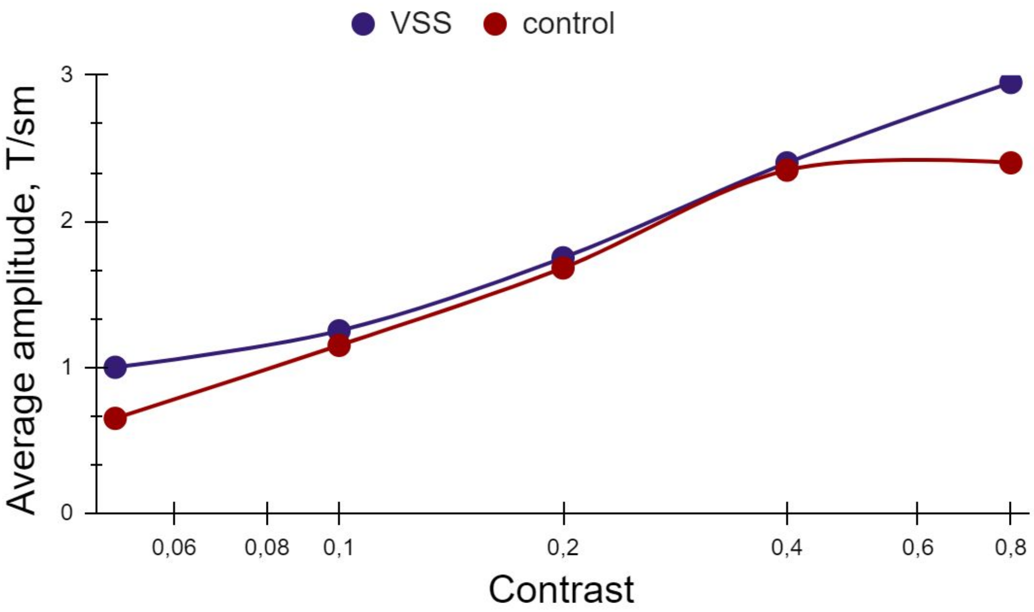


Fig.4. The total response amplitudes of subjects with VSS and control subjects

$$R = R_{max} \frac{c^2}{v^{2s} + c^{2s}} + b$$

Standard stimulus response model:
R - response magnitude,
c - stimulus contrast,
Rmax - maximum response,
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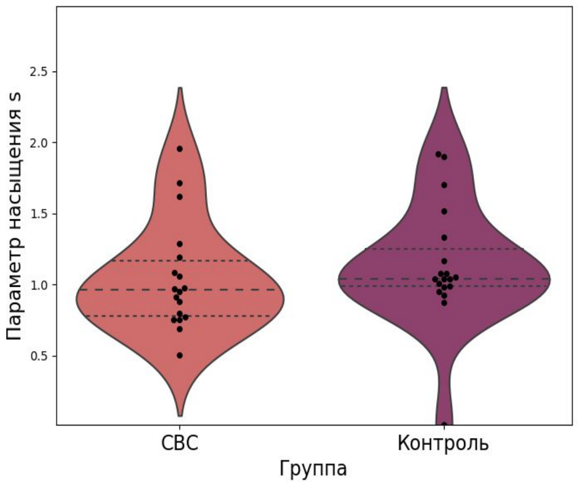
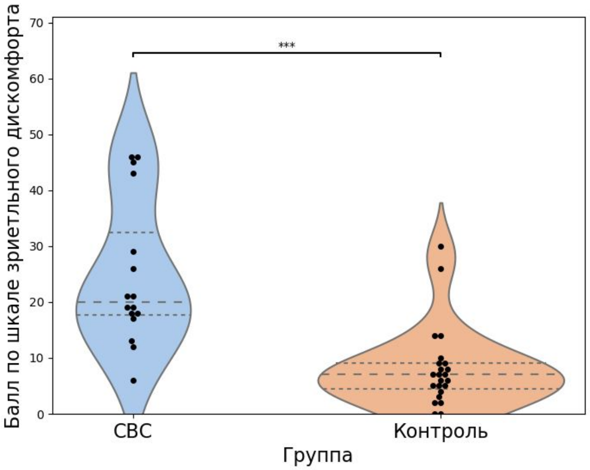
Preliminary results. Embedding a Contrast Gain Control Model



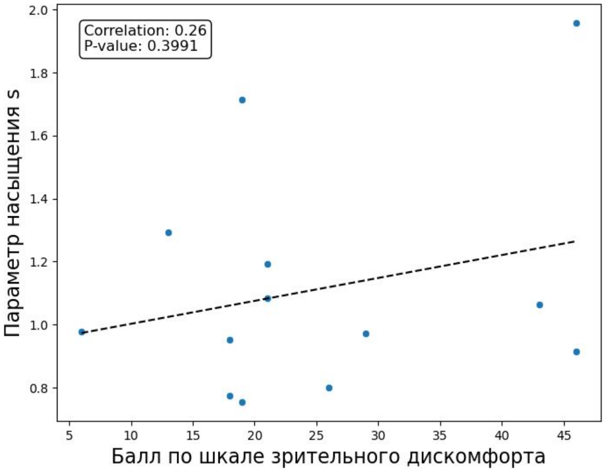
U-statistic	p-value
125.0	0.167

Distribution of the saturation degree parameter in the control group and the people with VSS



U-statistic	p-value
330.5	p<0.001

Distribution of visual discomfort scale scores in the control group and the group of people with VSS



r-value	p-value
0.26	0.3991

Correlation between saturation index s and visual discomfort level

Conclusions

1. **The saturation of contrast gain** in visual cortex responses, as measured by steady-state visual evoked fields, **does not differ between individuals with visual snow syndrome and control subjects.**

2. **The level of visual discomfort** associated with viewing high-contrast visual patterns **is increased in individuals with visual snow syndrome** compared to the control group.

3. The lack of correlation between the level of visual discomfort and contrast gain saturation suggests that this feature of **visual cortex excitability is not the primary cause of visual discomfort** in visual snow syndrome.

References

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