Kurt Steinmetzger & Stuart Rosen

The role of periodicity in perceiving speech in quiet and in background noise

Speech in Noise 2015 Workshop,
Copenhagen, 8–9 January

Background: periodicity = voicing

1. Segregating speech and noise

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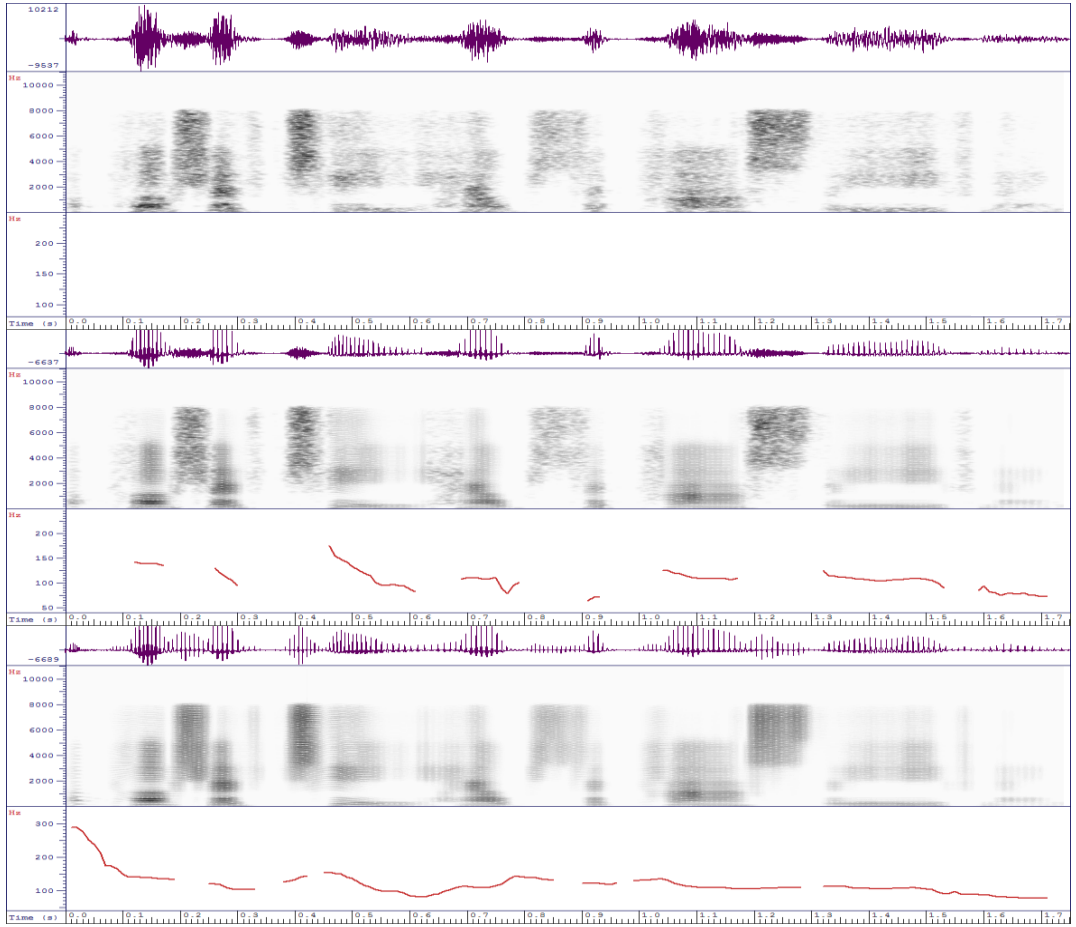
However, it is unclear to date whether TFS information plays a *special role in glimpsing* or is just as important for steady maskers.

Stimuli: speech with and without periodicity



Noise-vocoding

Dudley-vocoding

F0-vocoding

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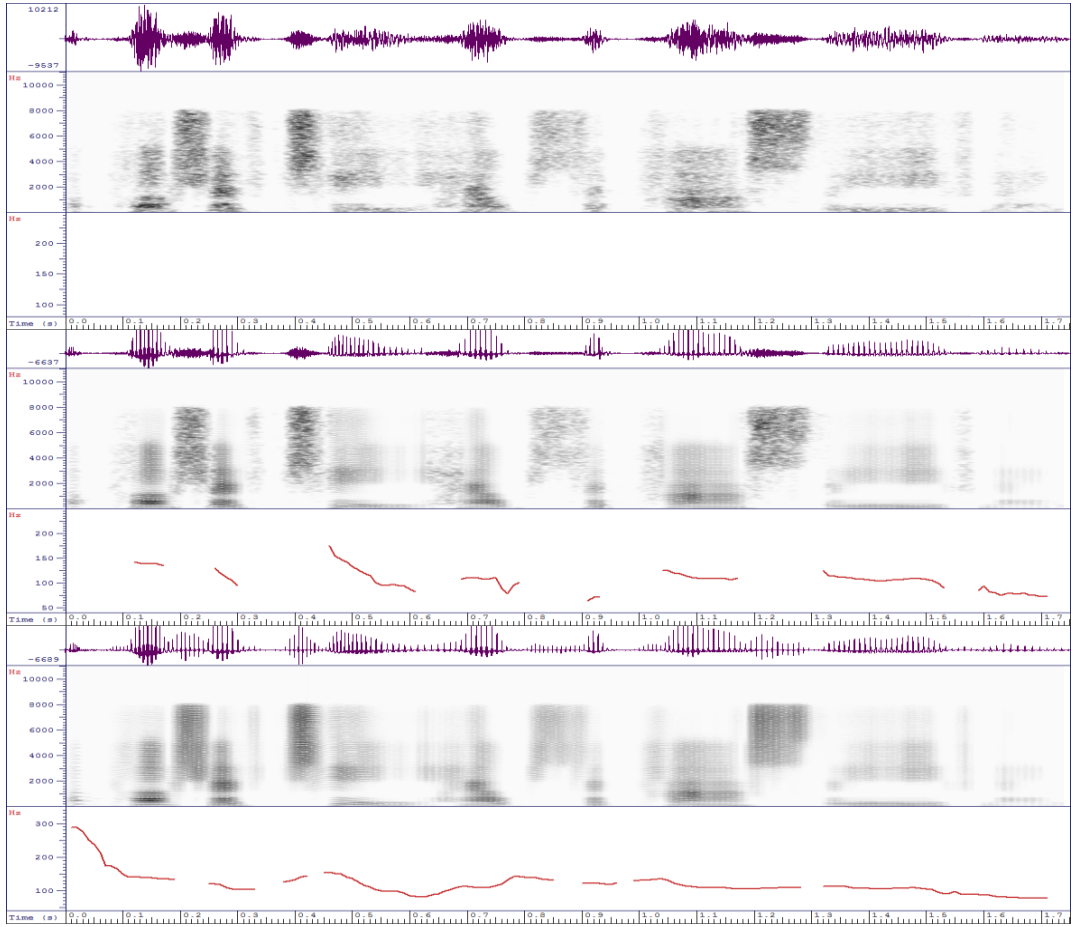
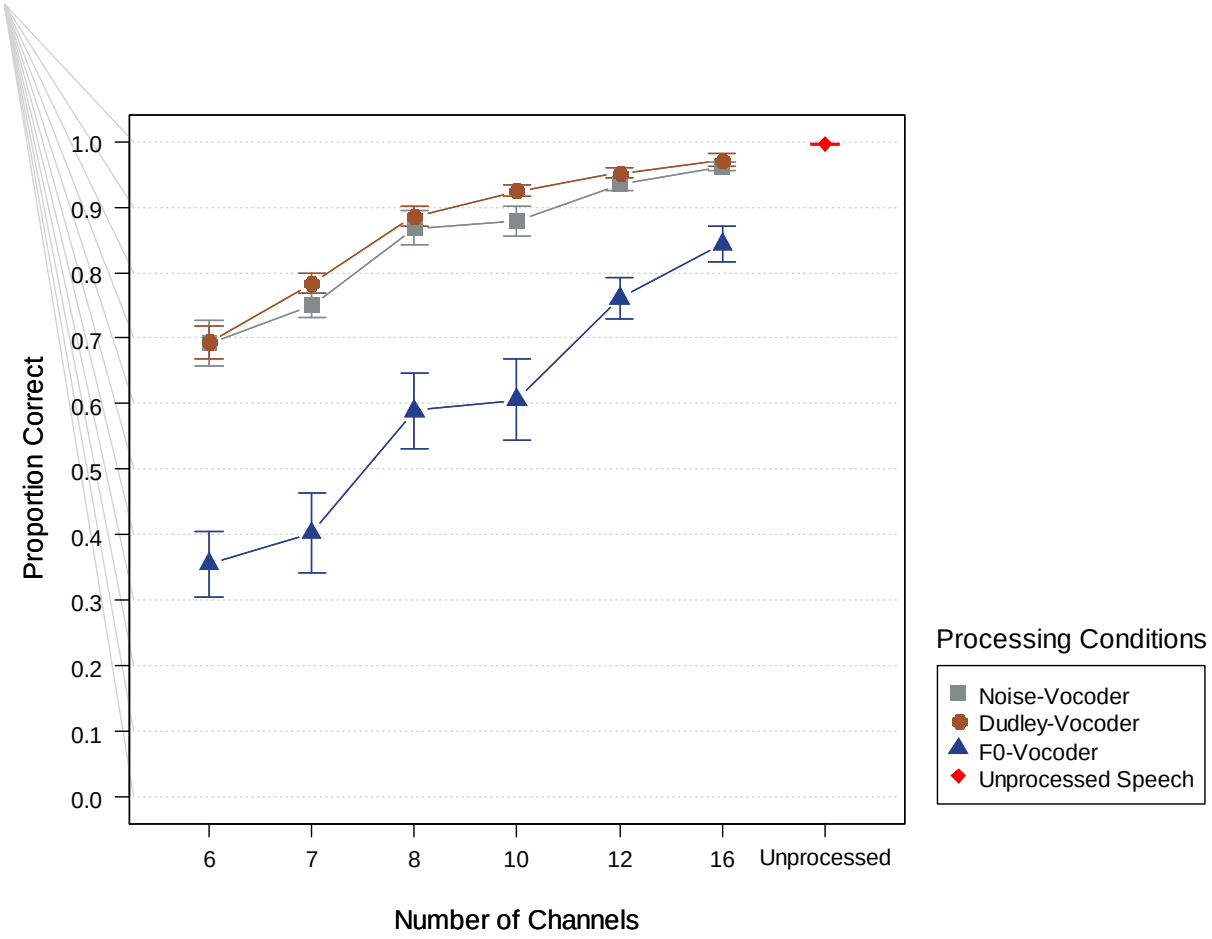


Noise-vocoding
– no periodicity

Dudley-vocoding
– mostly periodic

F0-vocoding
– completely periodic

Experiment 1: Periodicity in the target speech



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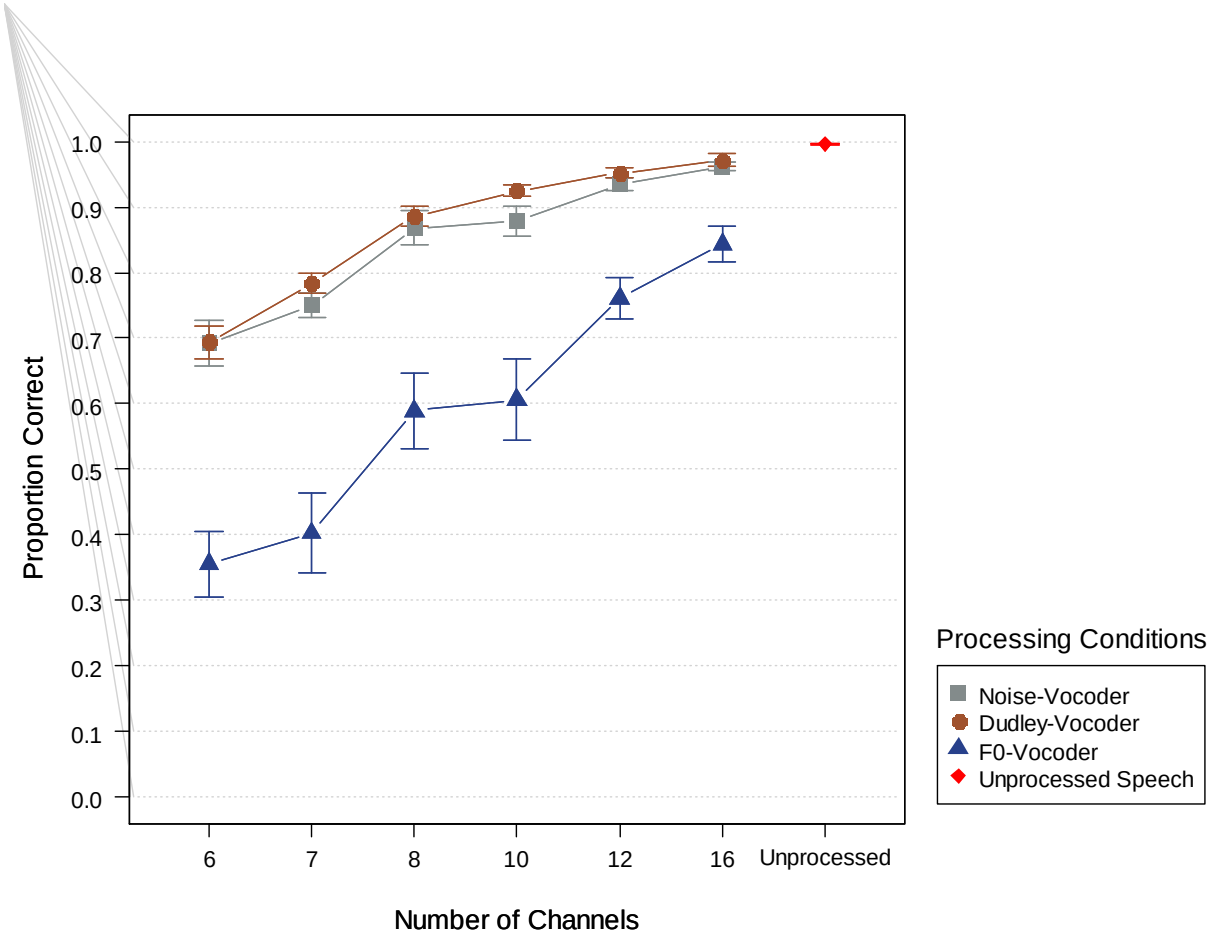

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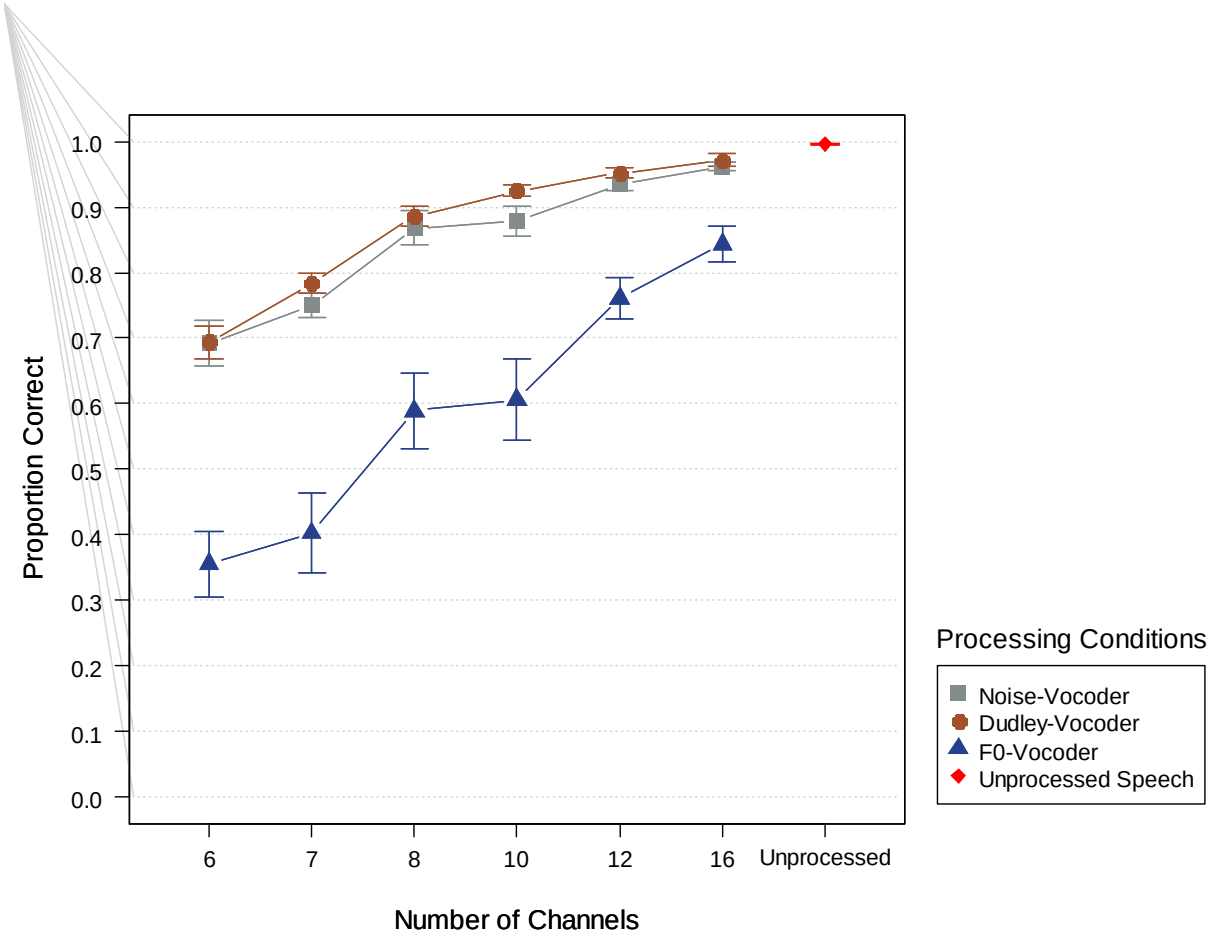

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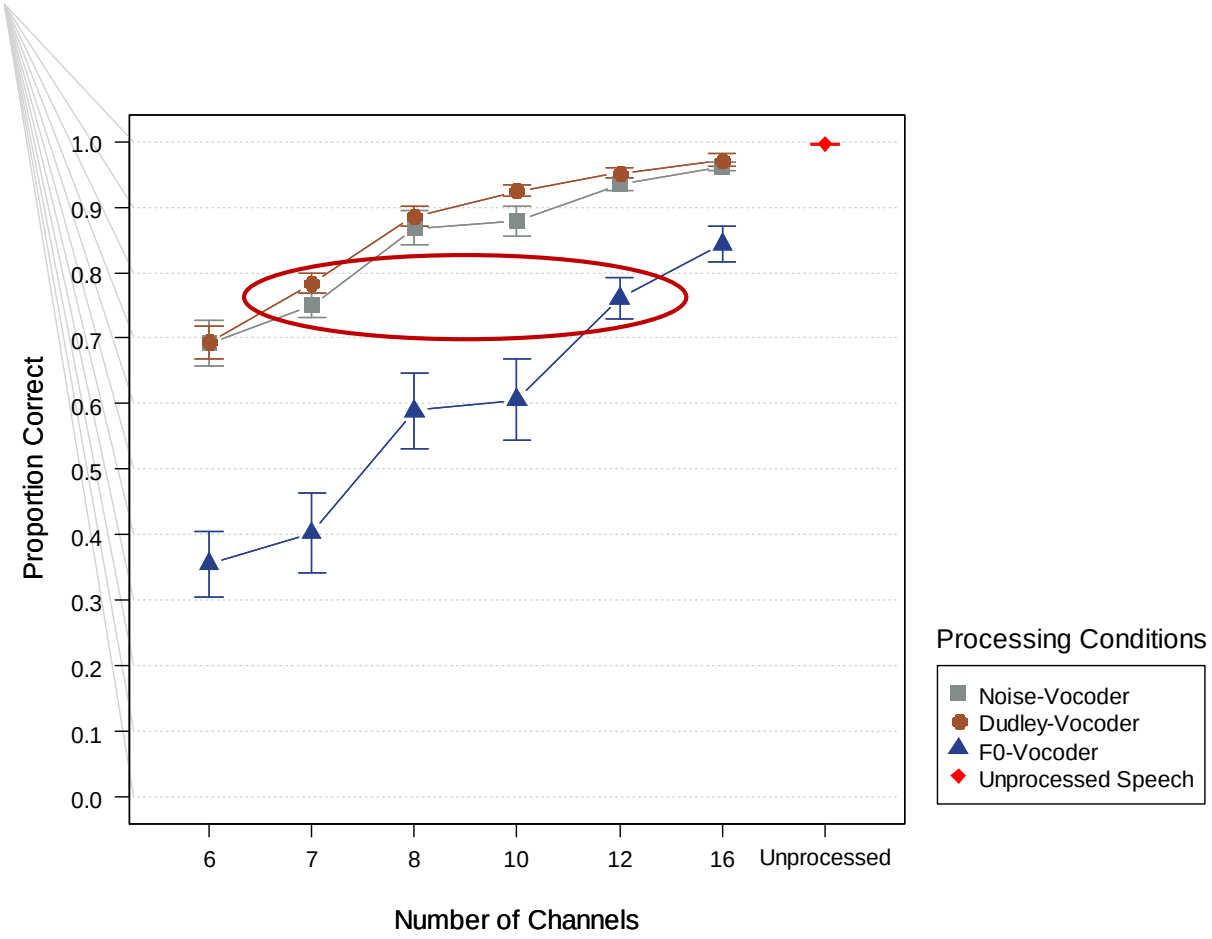

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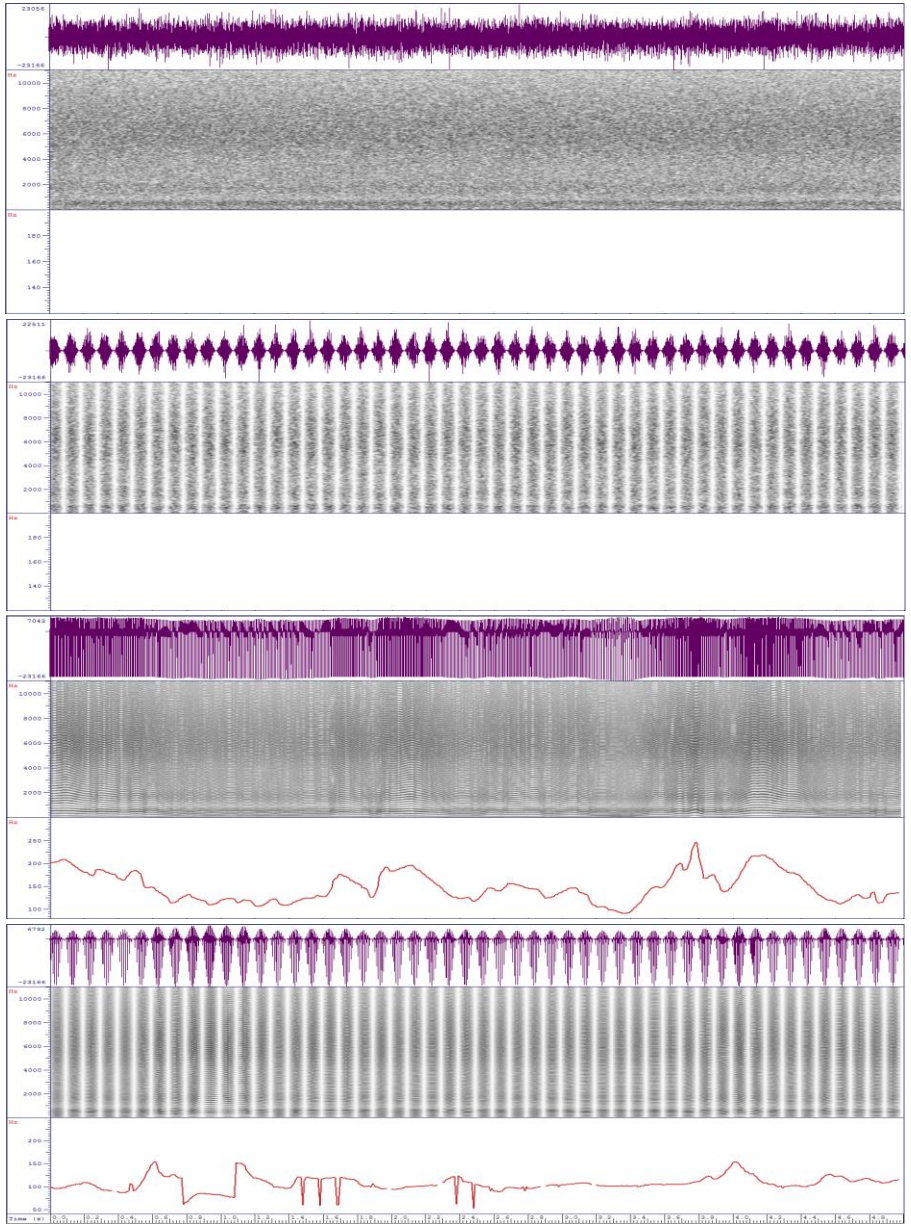

Steady speech-shaped noise

10 Hz-modulated speech-shaped noise

Steady harmonic complex

10 Hz-modulated harmonic complex

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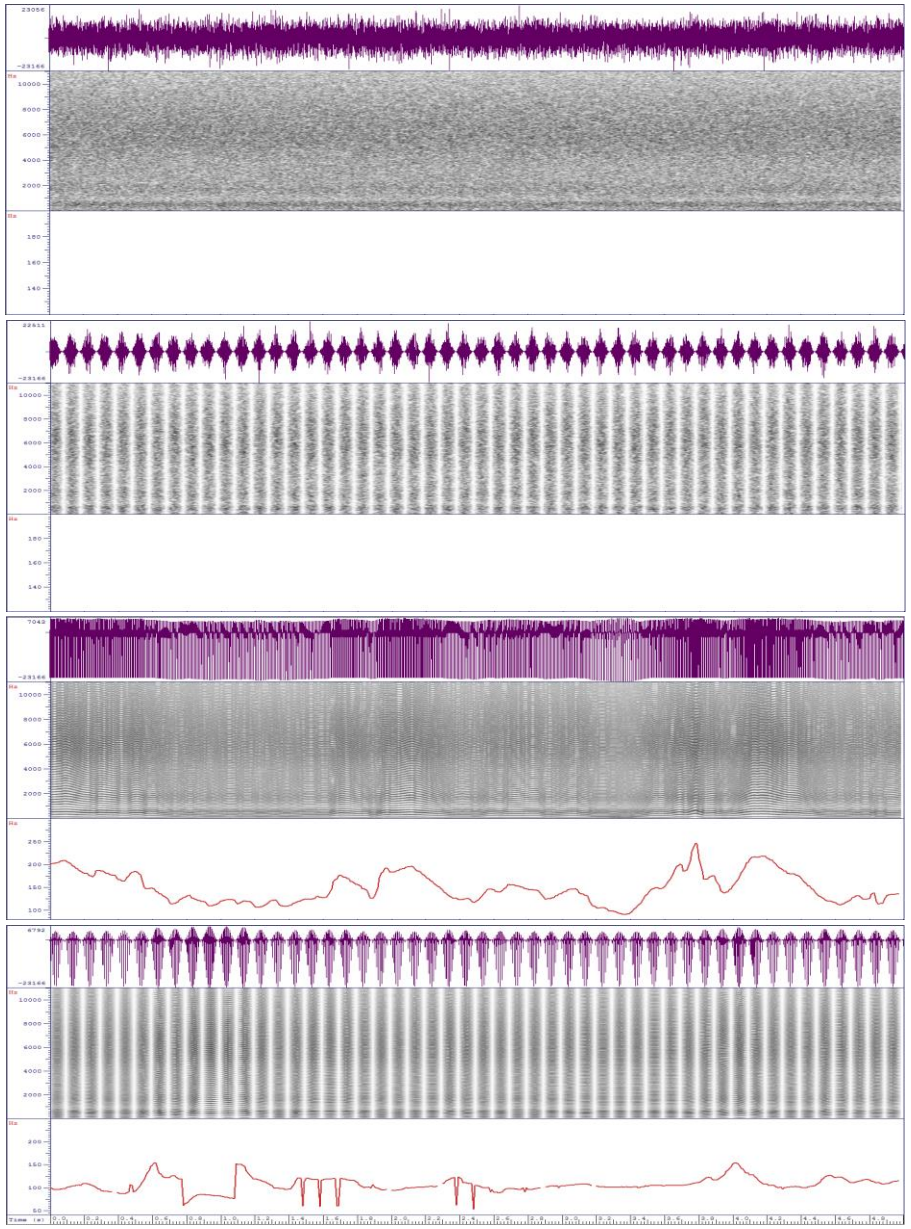


Steady speech-shaped noise
– no periodicity

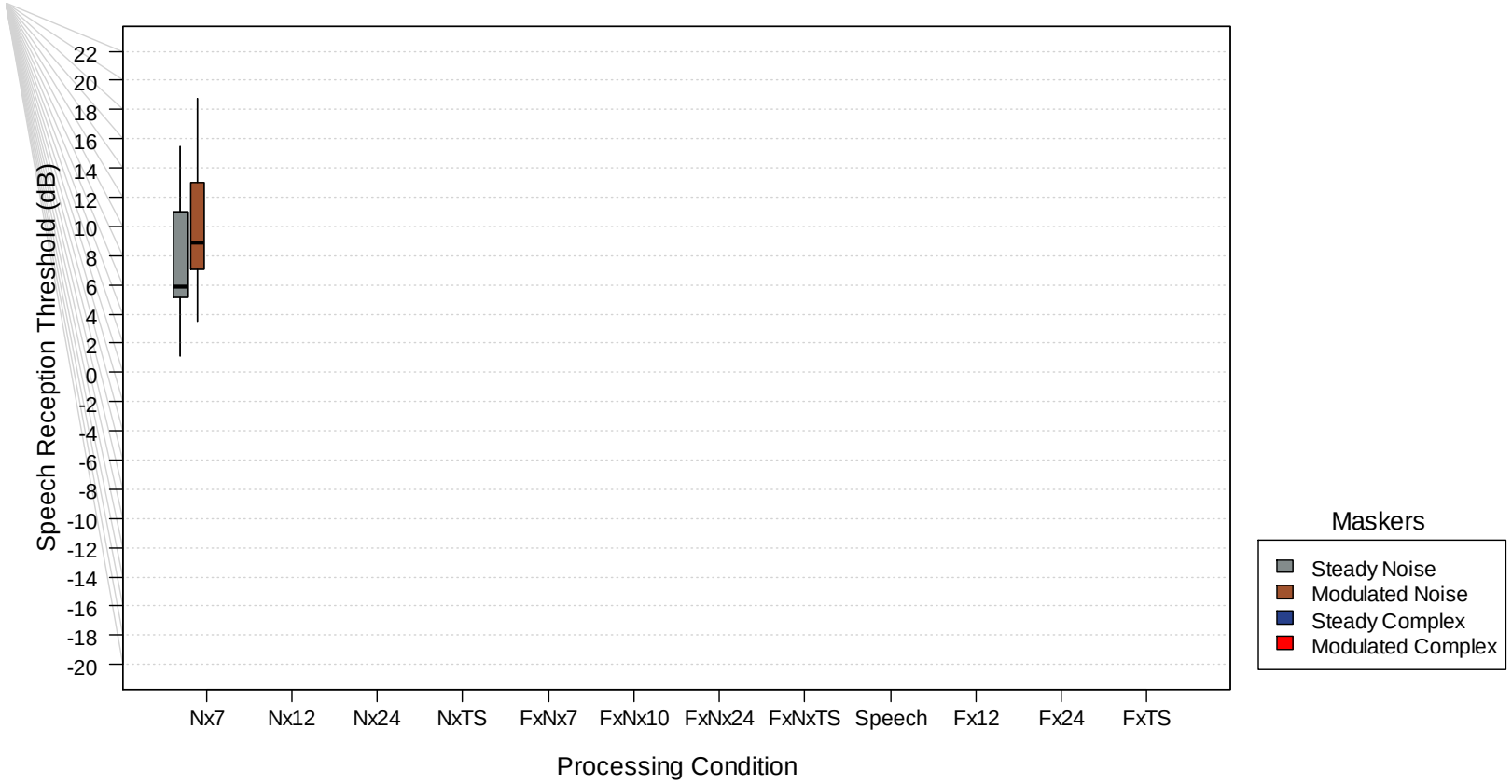
10 Hz-modulated speech-shaped noise
– no periodicity

Steady harmonic complex
– completely periodic

10 Hz-modulated harmonic complex
– completely periodic

Experiments 2+3: Periodicity in target speech and masker

1. Speech Reception Threshold



Aperiodic noise maskers:

Modulation interference when intelligibility of the target speech is lowered (~75%).

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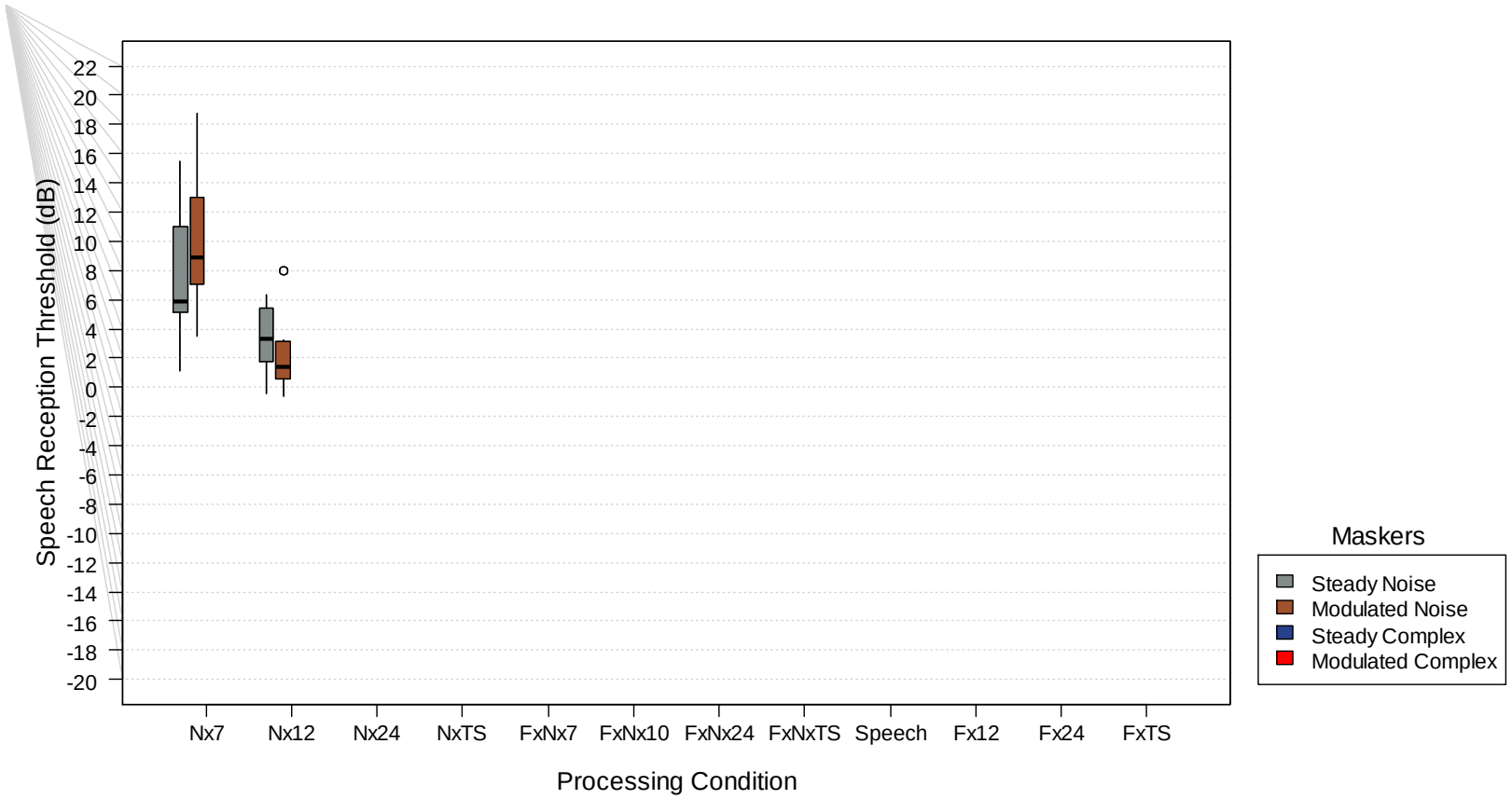

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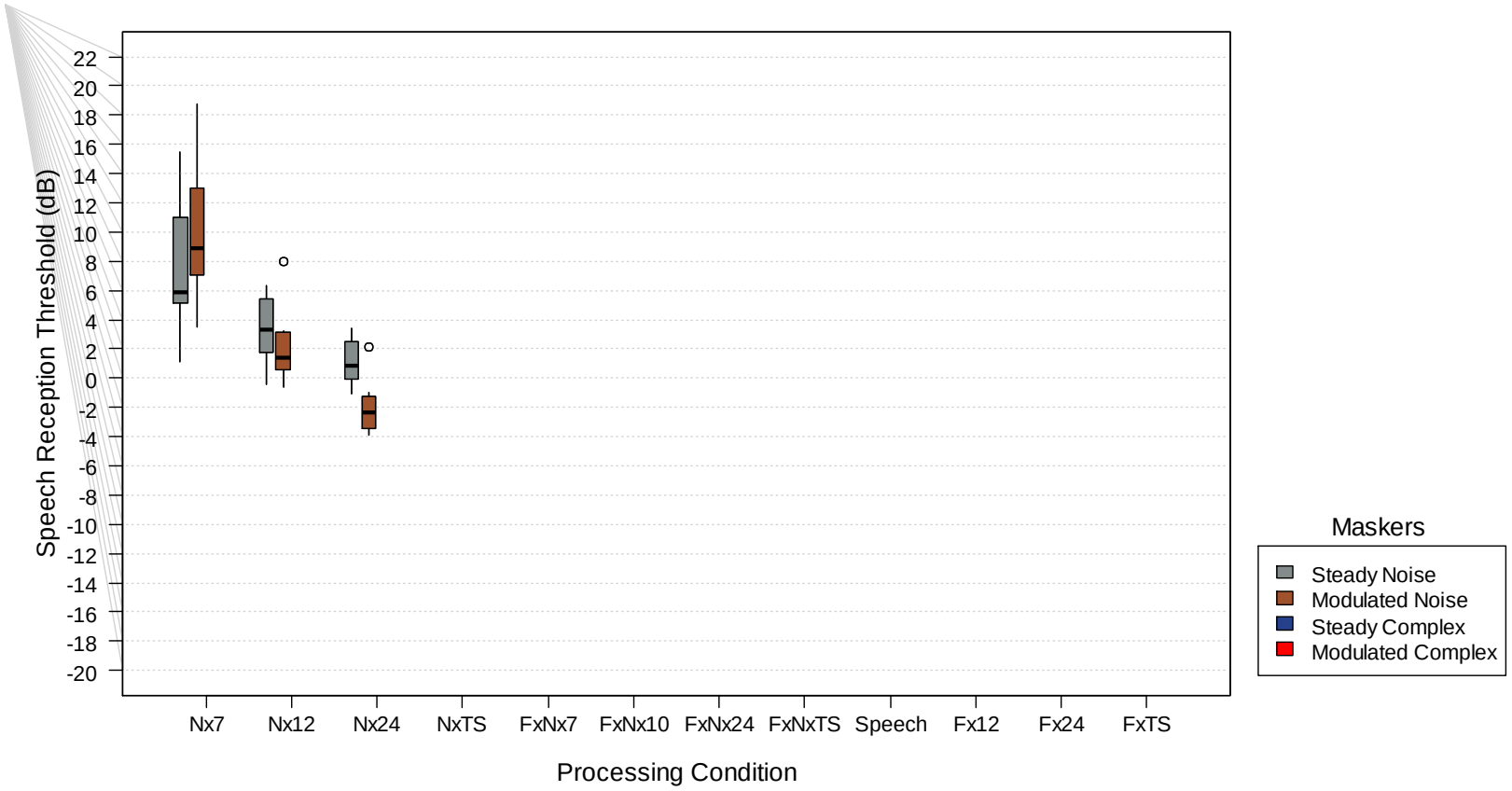

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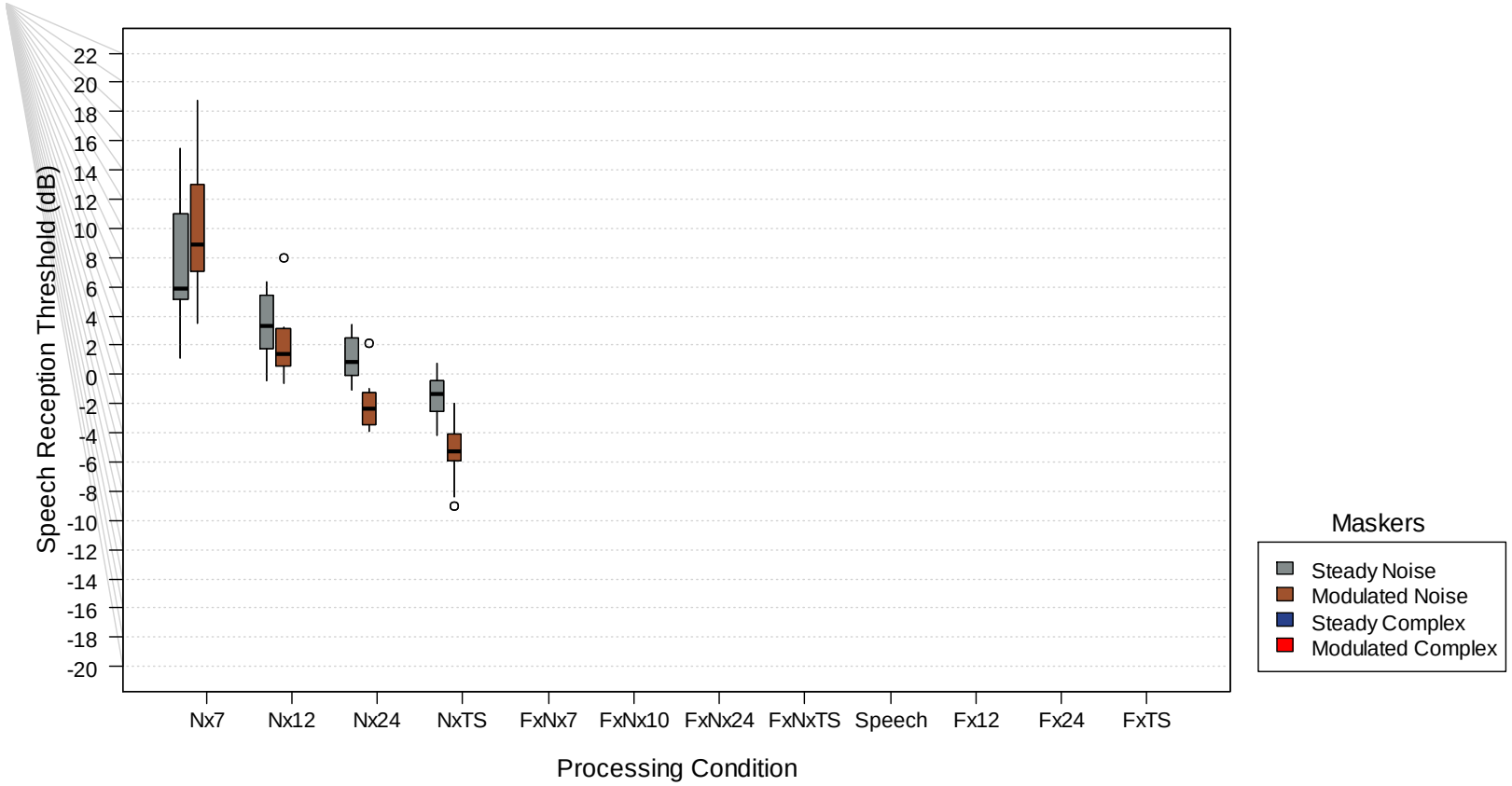

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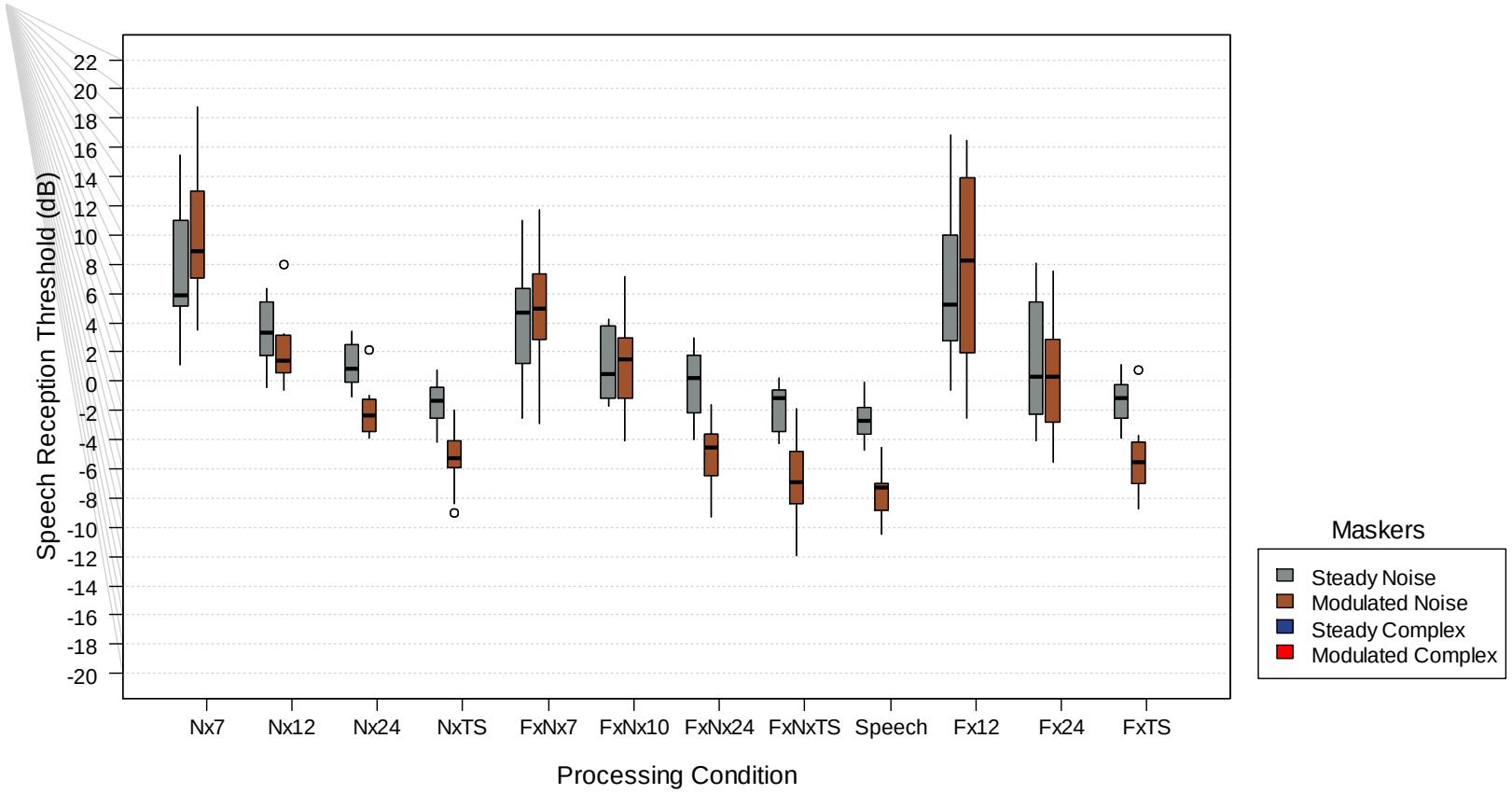

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Performance improves slightly with more *periodicity in the target speech.*

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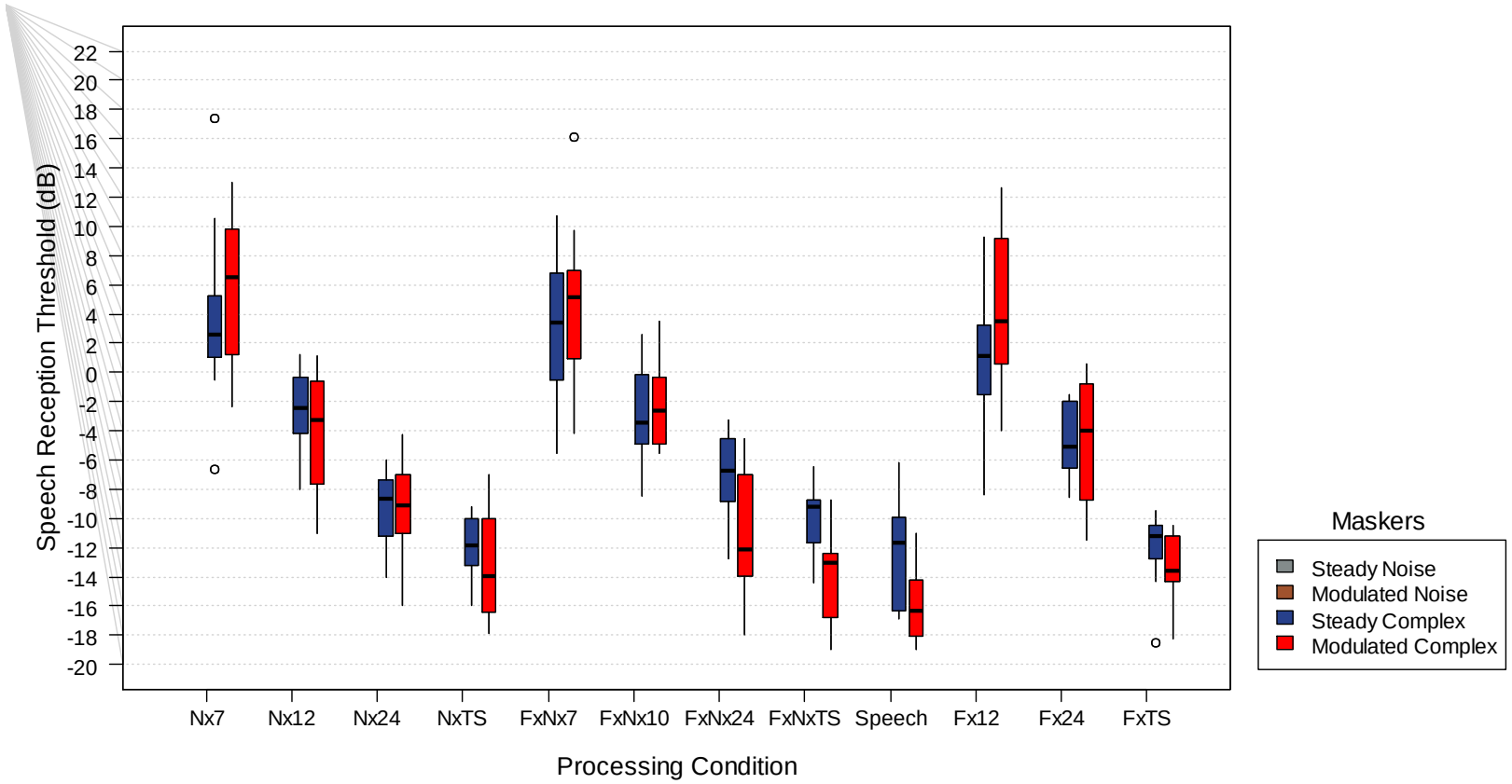

Periodic complex maskers:

Better performance (i.e. *lower SRTs*) throughout when masker is periodic.

Same pattern of results: Performance is slightly better with more periodicity in the target speech.

Experiments 2+3: Periodicity in target speech and masker

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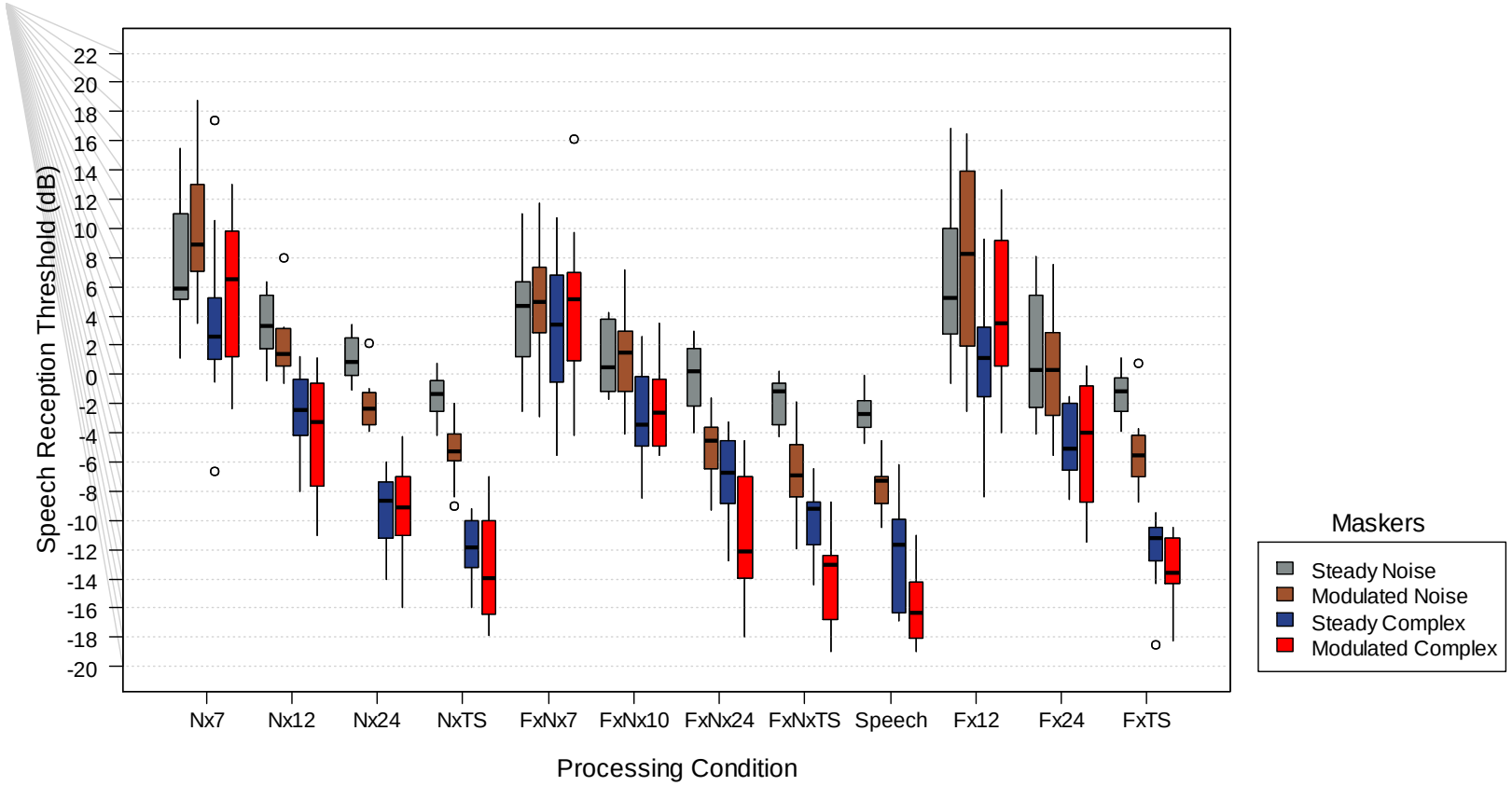


In summary:

As intelligibility of targets increases from 75% to 100%, SRTs drop by about *25 dB*.

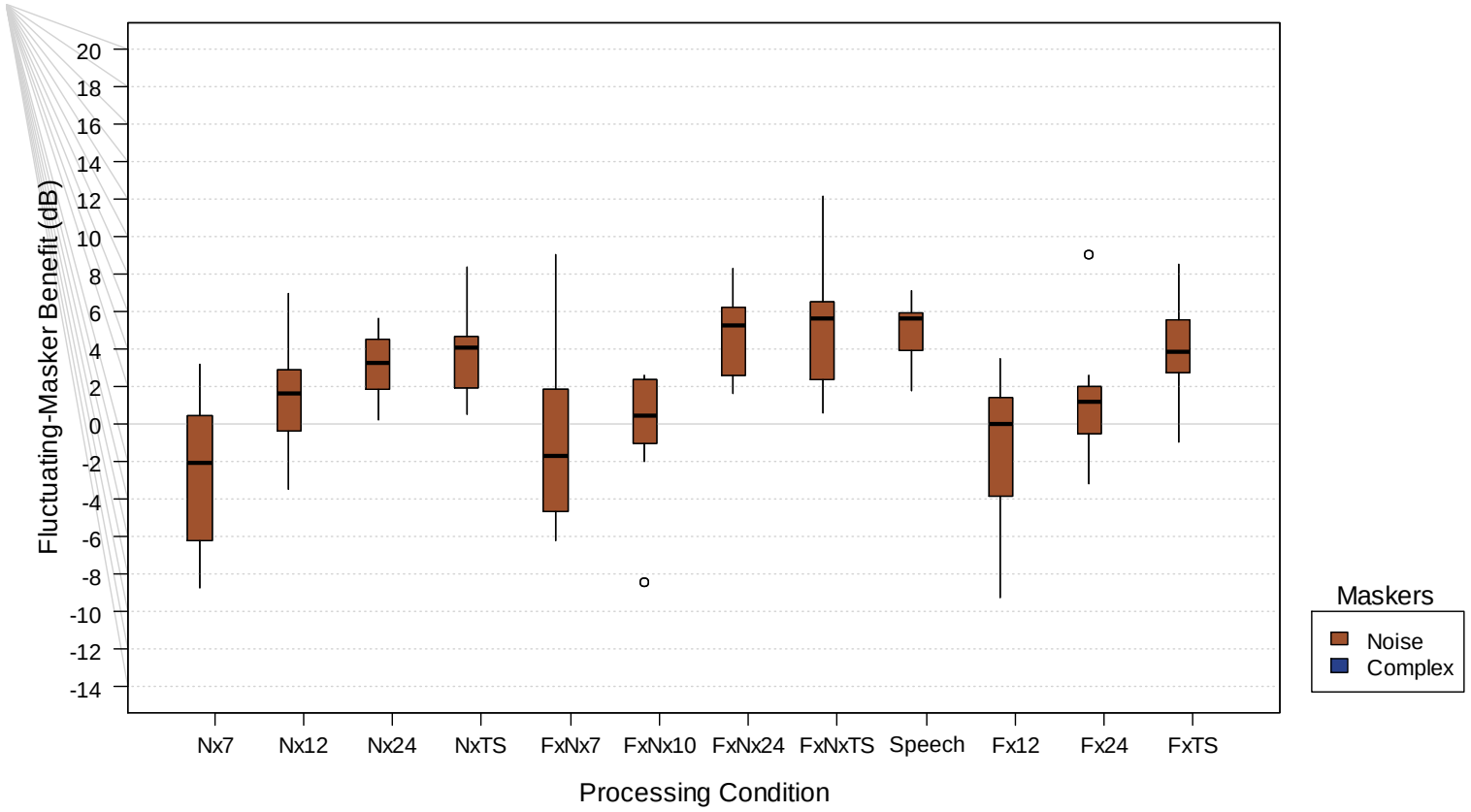
Glimpsing requires high intelligibility of target speech.

Periodic maskers are much less effective.

Surprisingly small effect of target periodicity.

Experiments 2+3: Periodicity in target speech and masker

2. Fluctuating-Masker Benefit



SRT of *steady masker* minus SRT of *modulated masker*:

Largest benefit when target speech has a mixed source (and intelligibility is at ceiling): ~ 6 dB.

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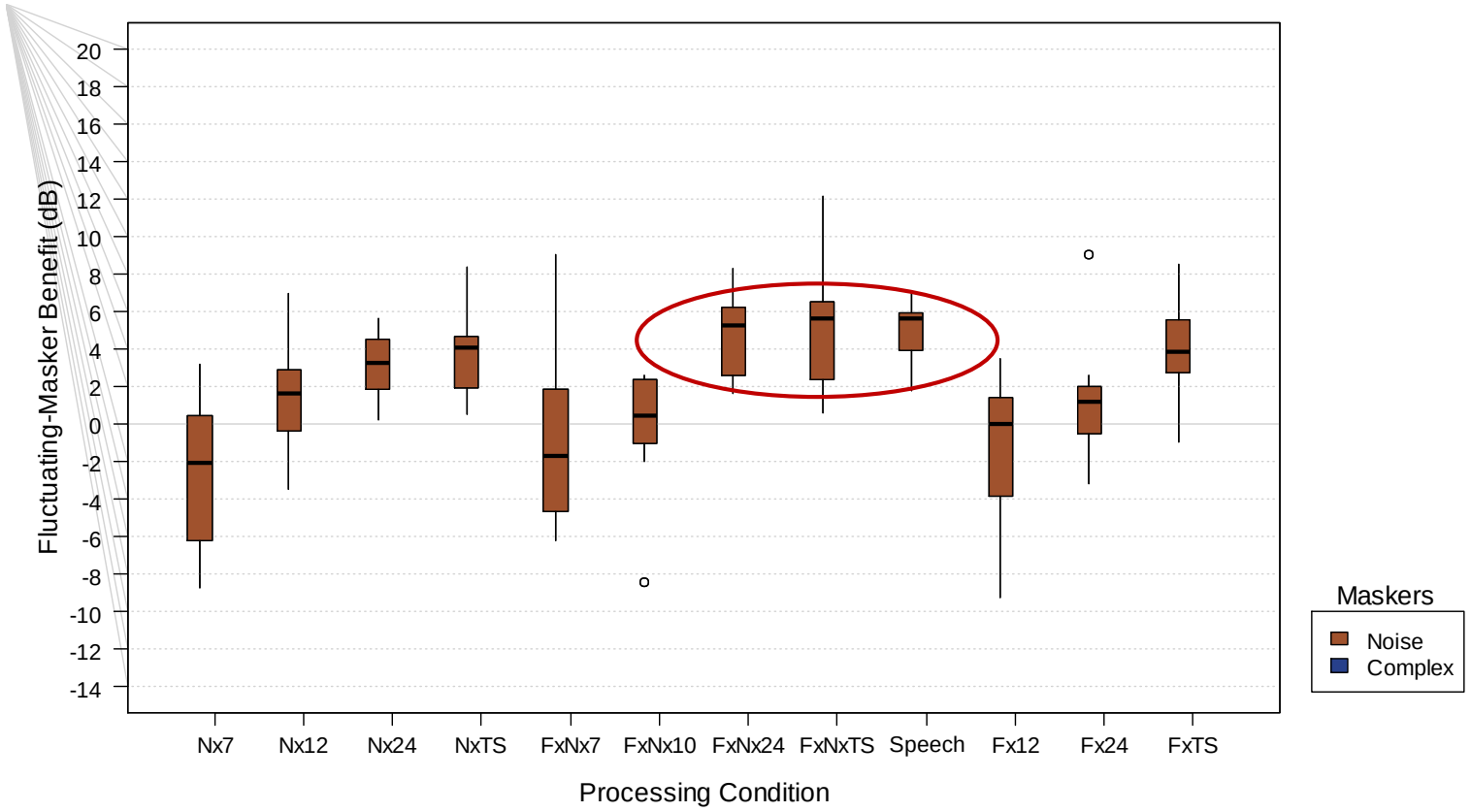

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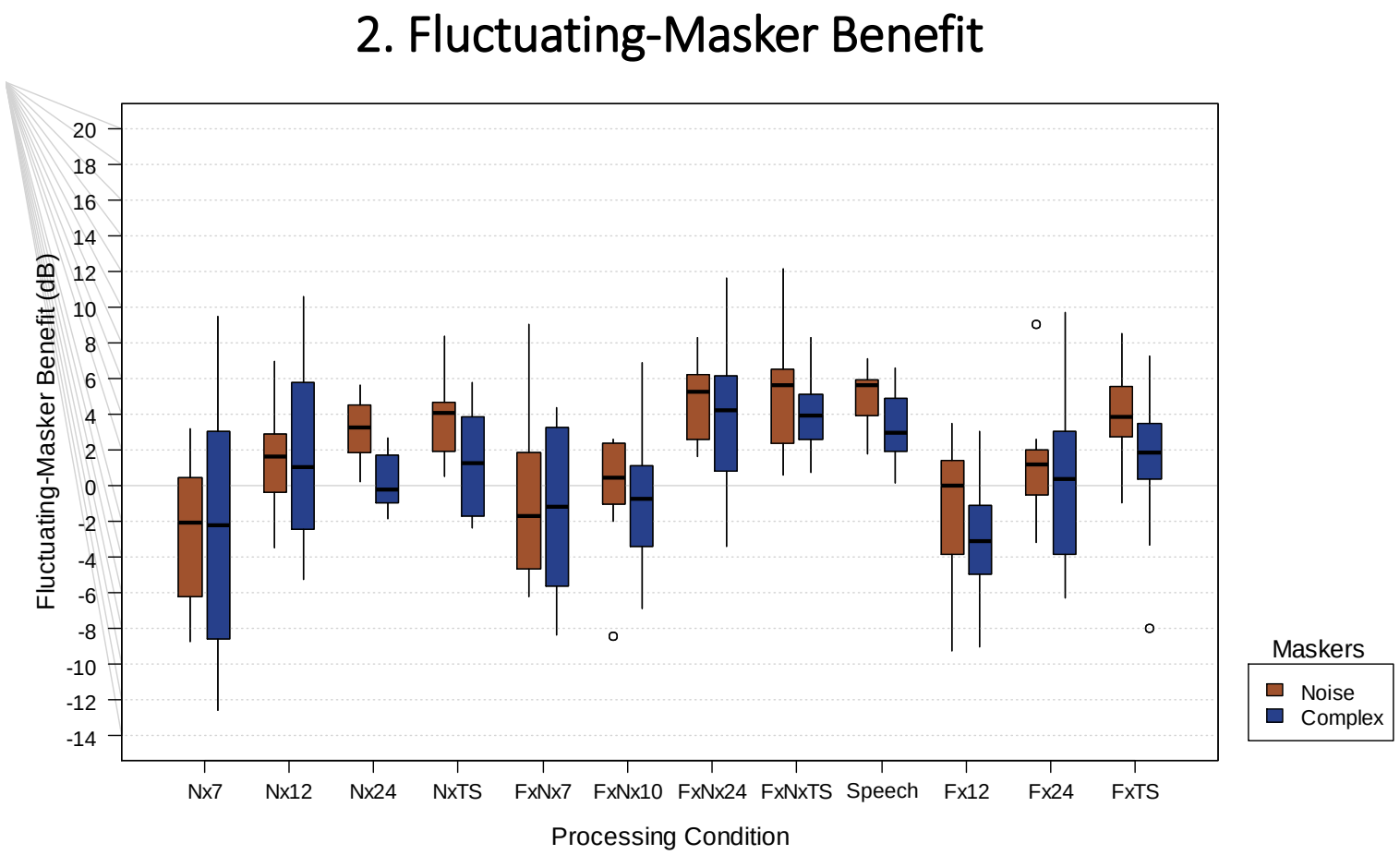

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More glimpsing when masker is aperiodic.

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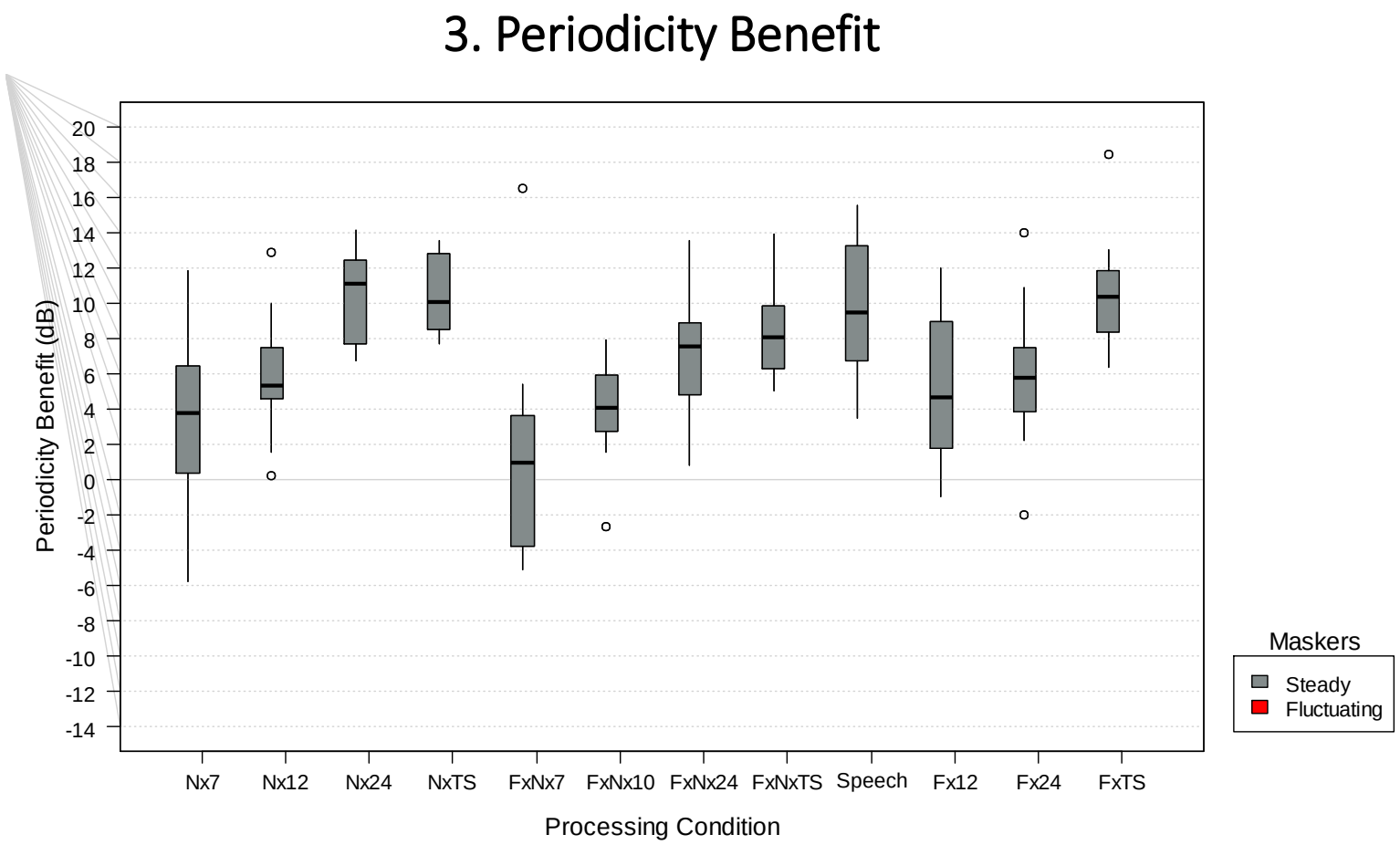

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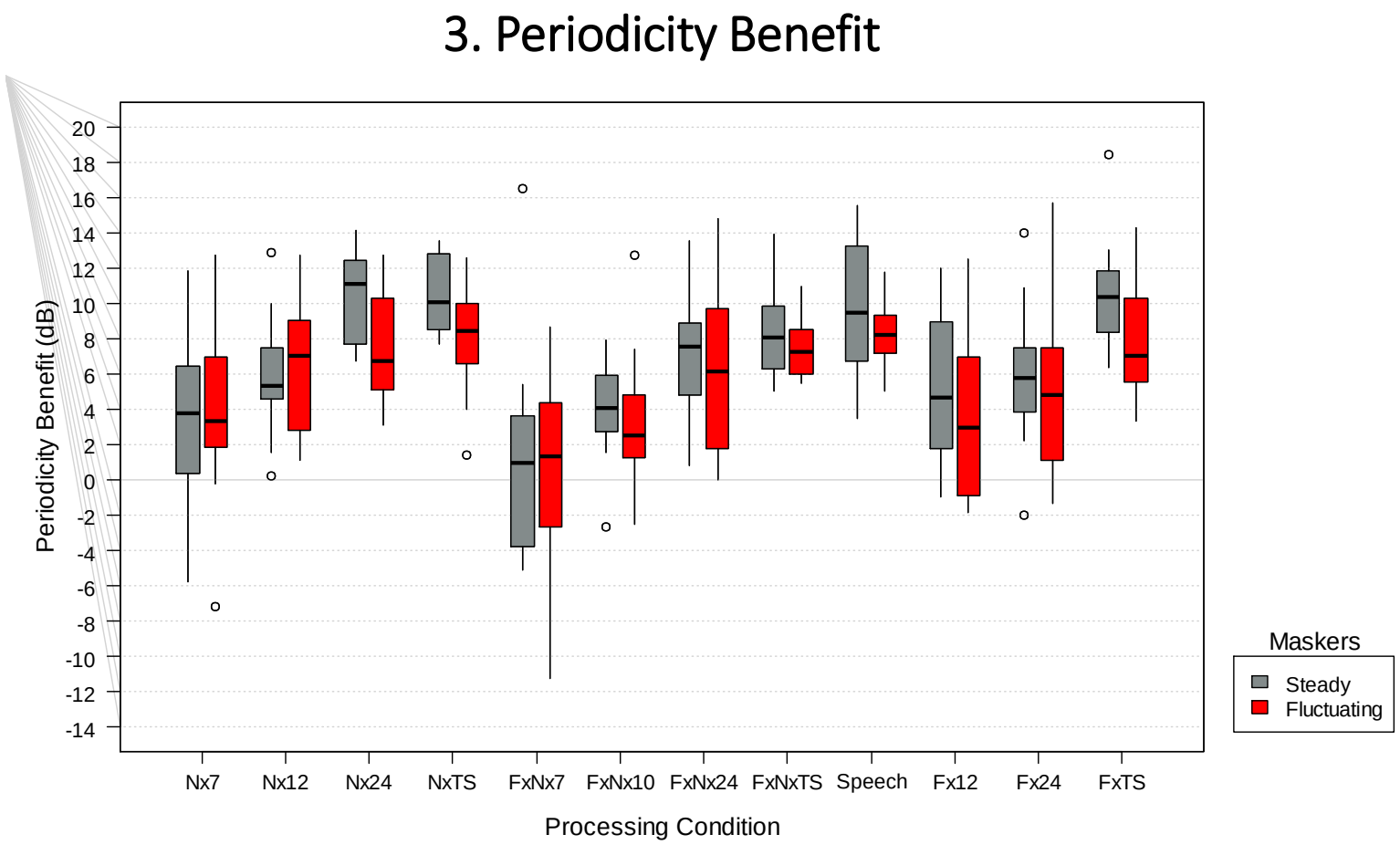

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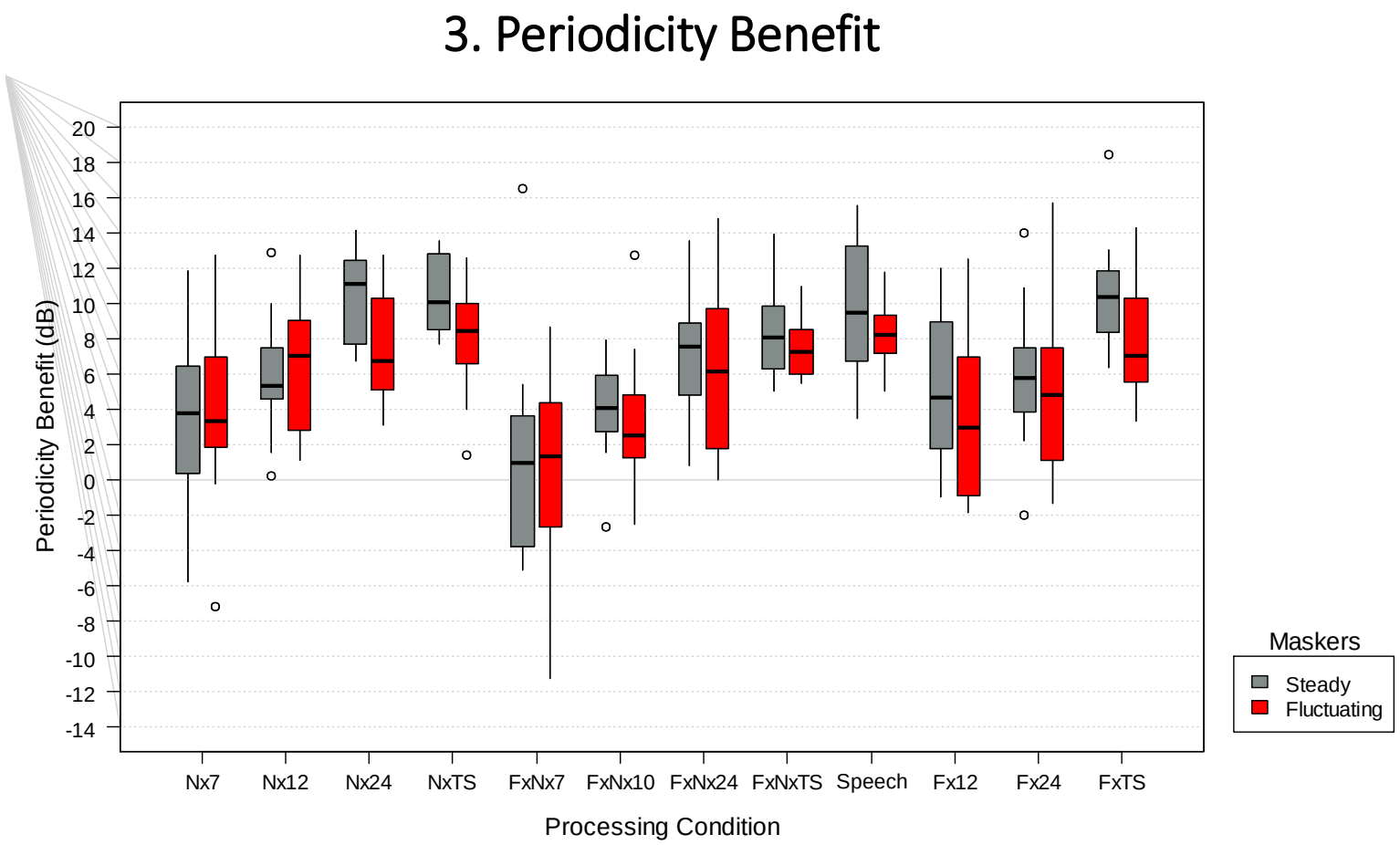

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Listeners *always* benefit from periodicity in the masker.

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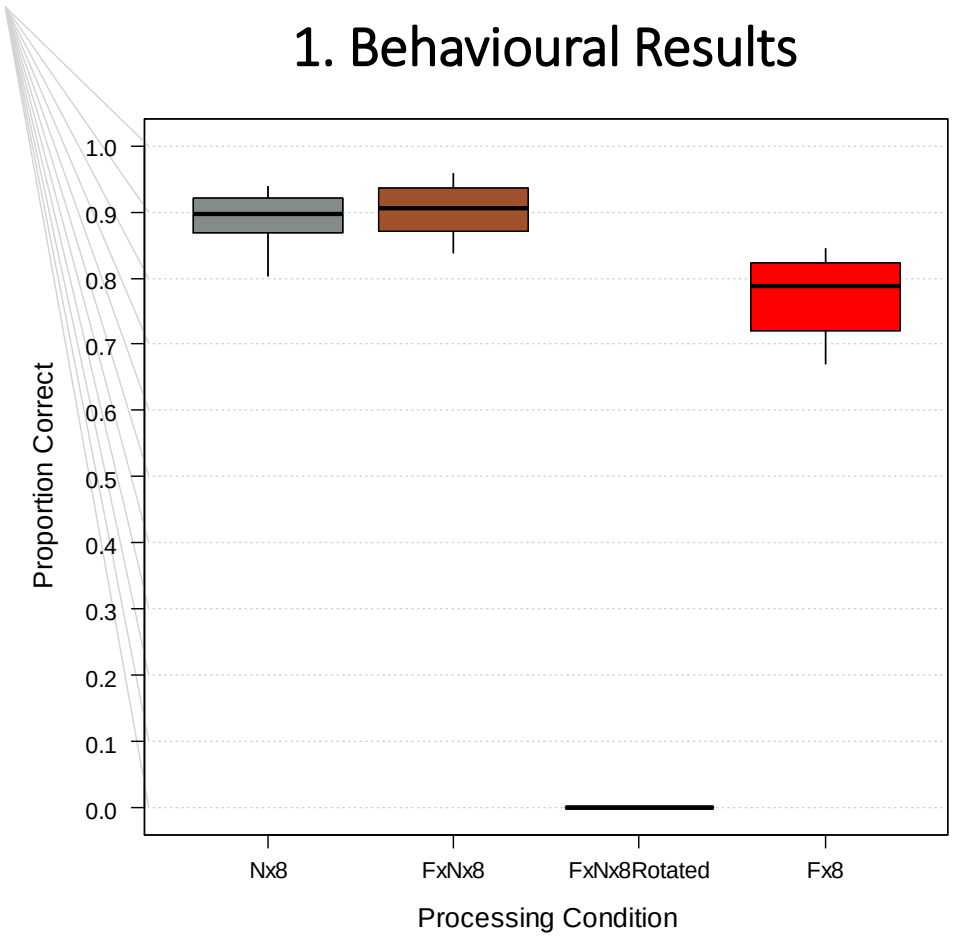

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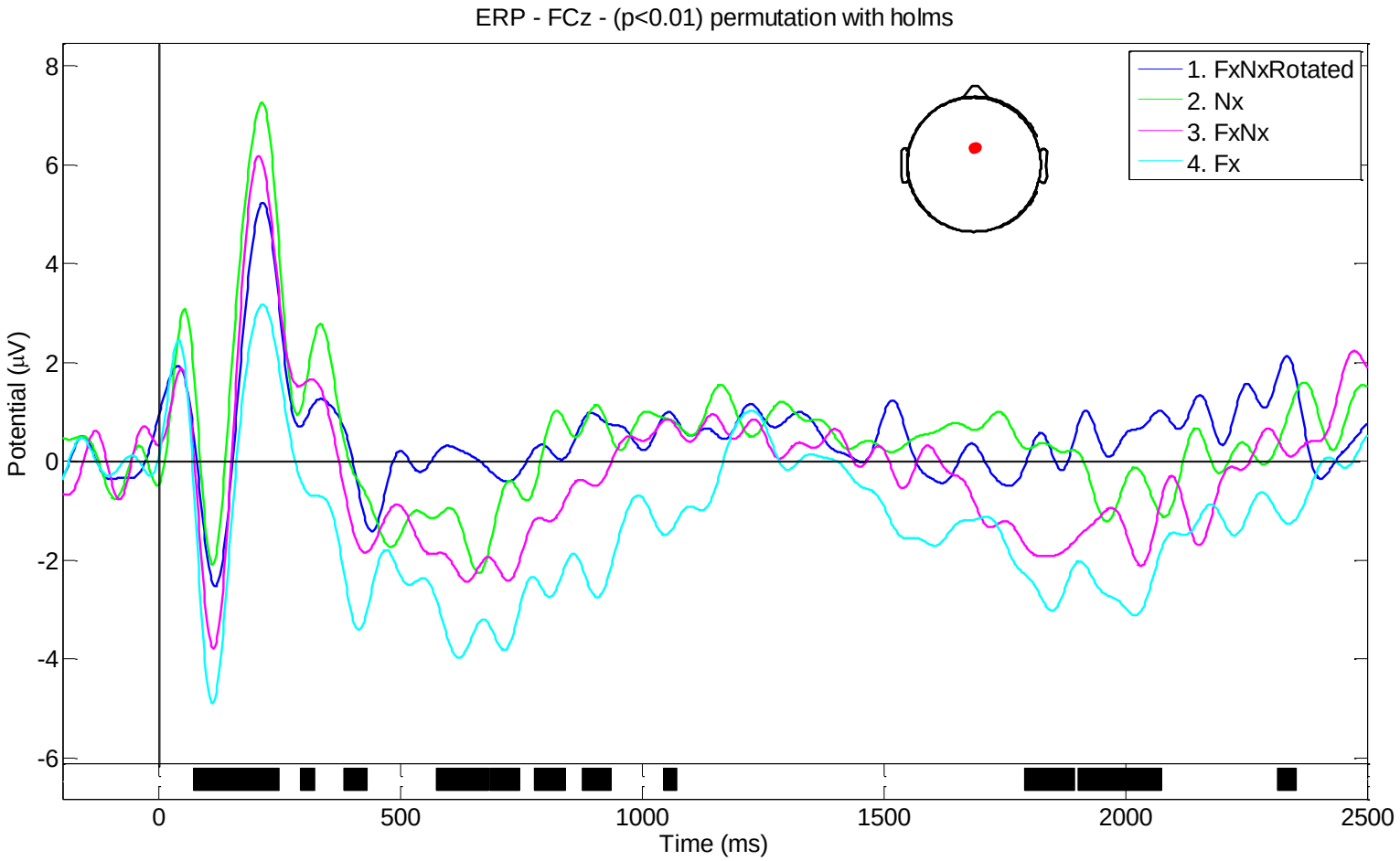

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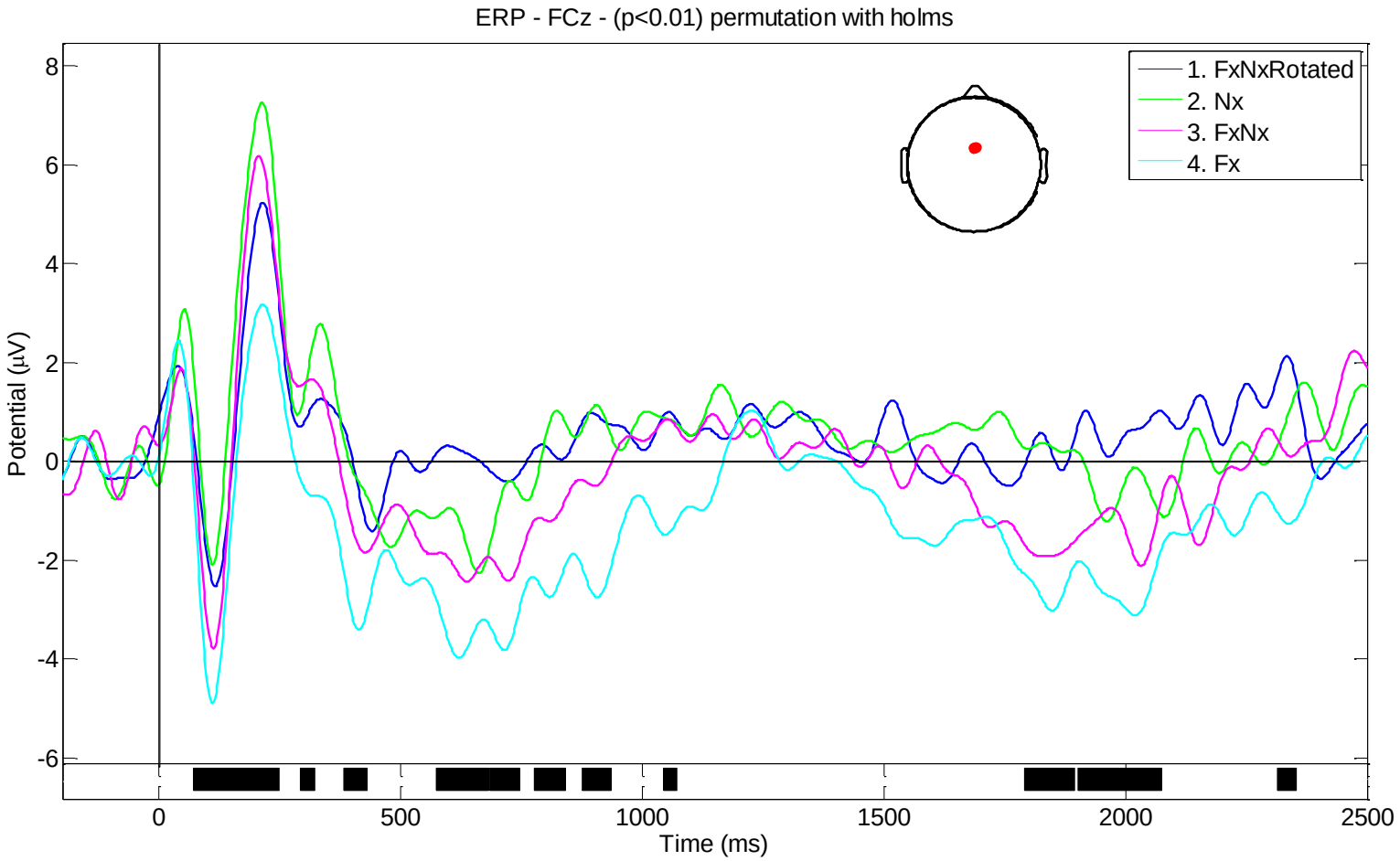

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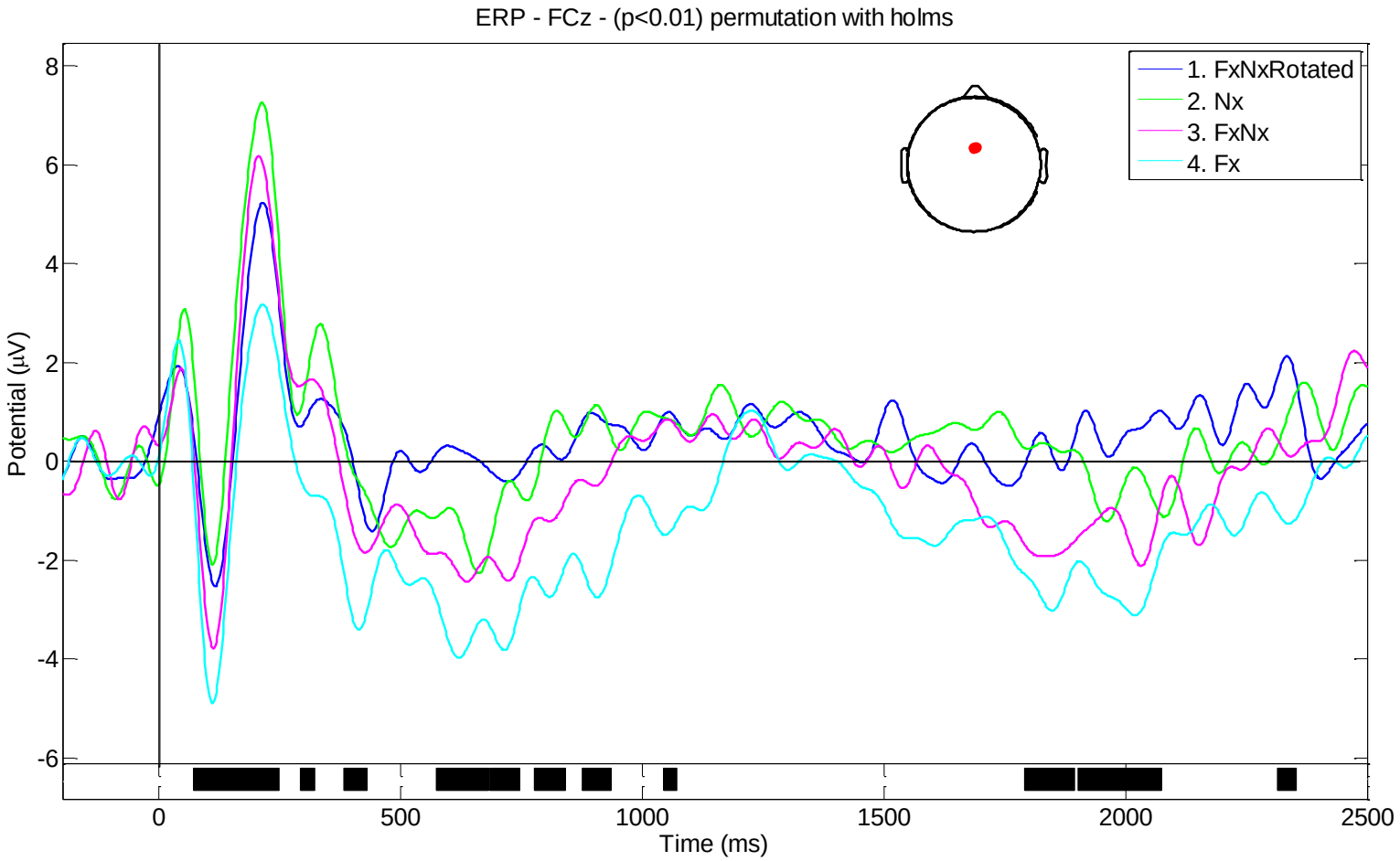

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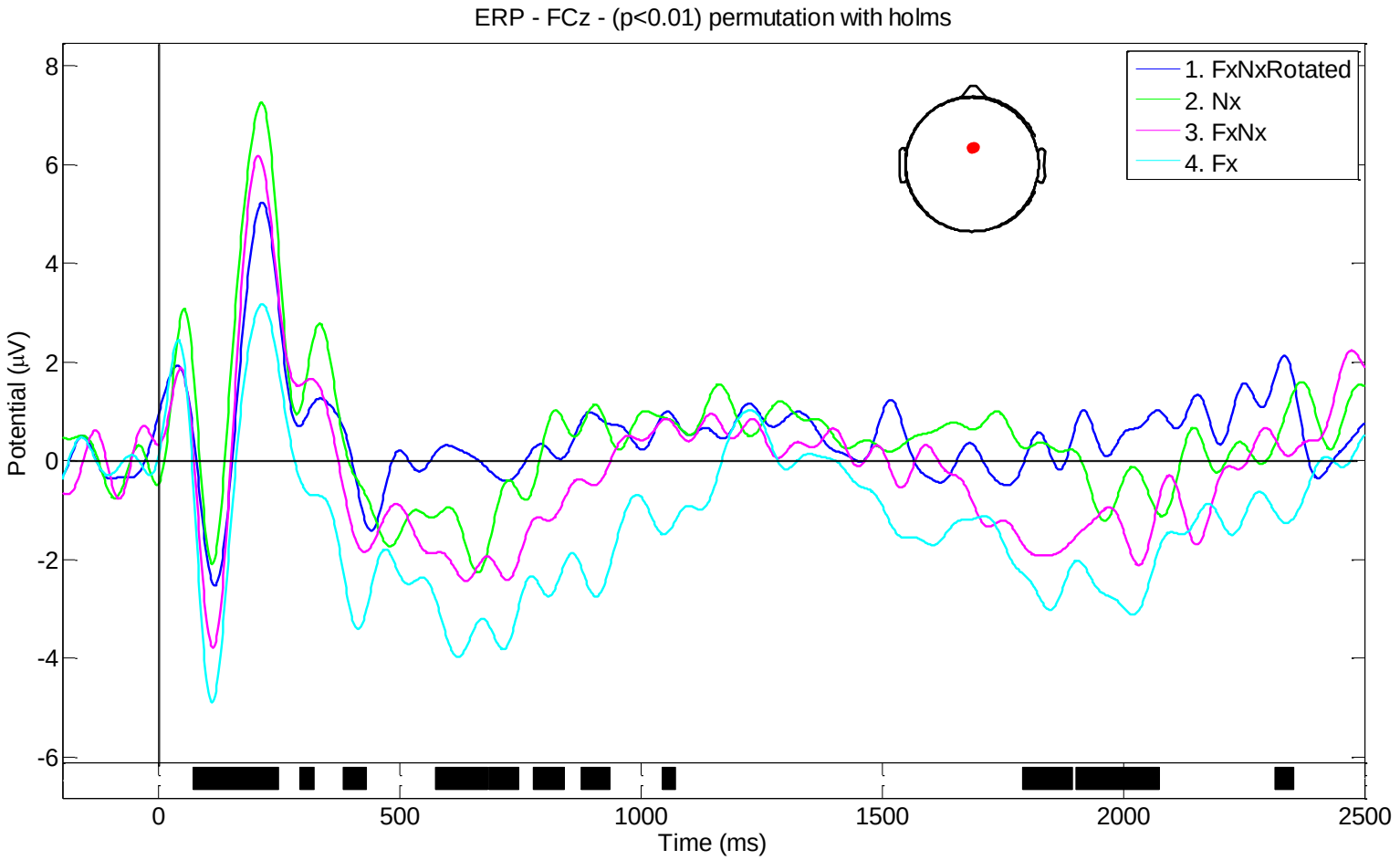

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Differences in intelligibility have been *controlled* for.

Auditory cortex seems to be *more sensible* to tonal (periodic) stimuli.

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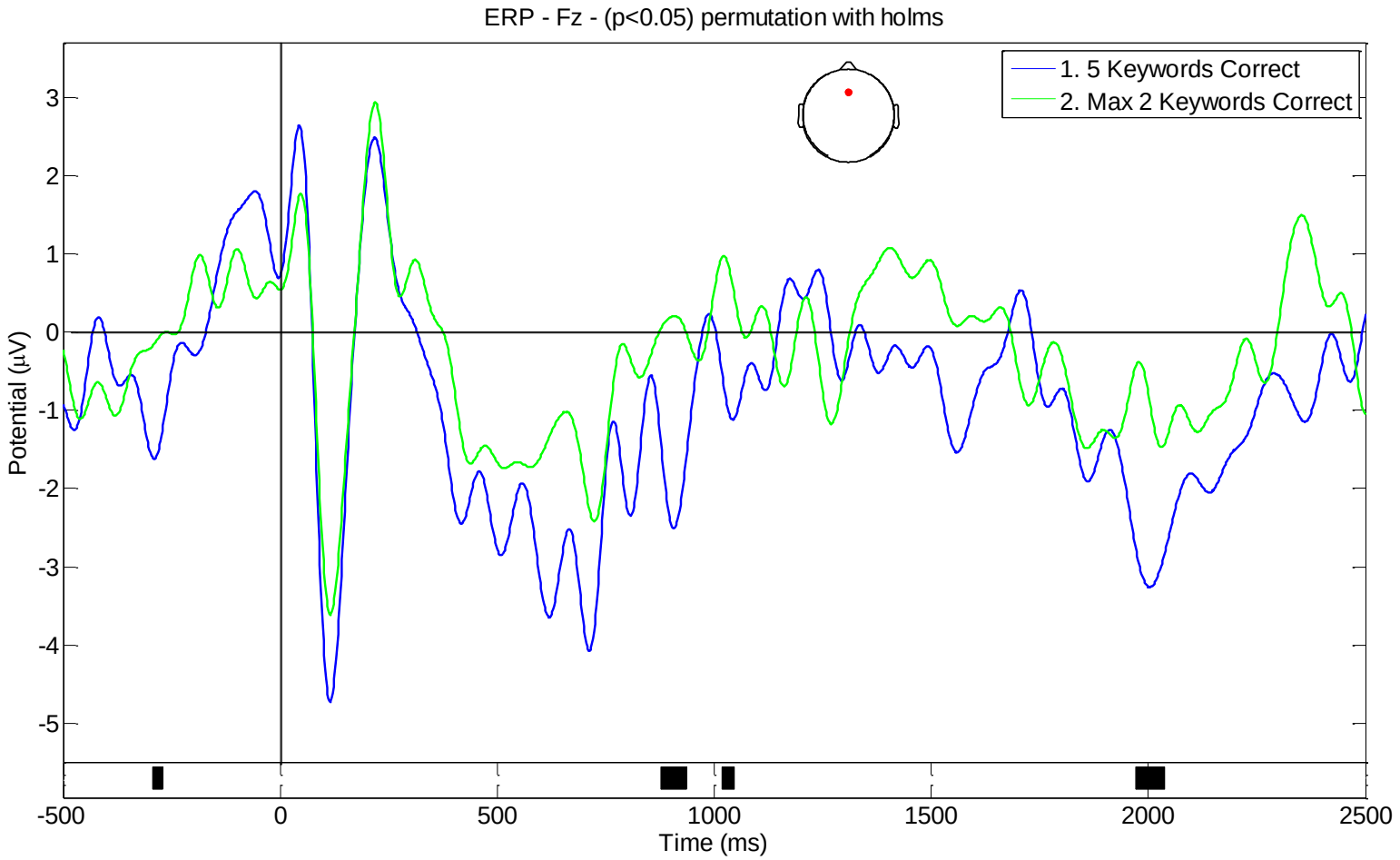

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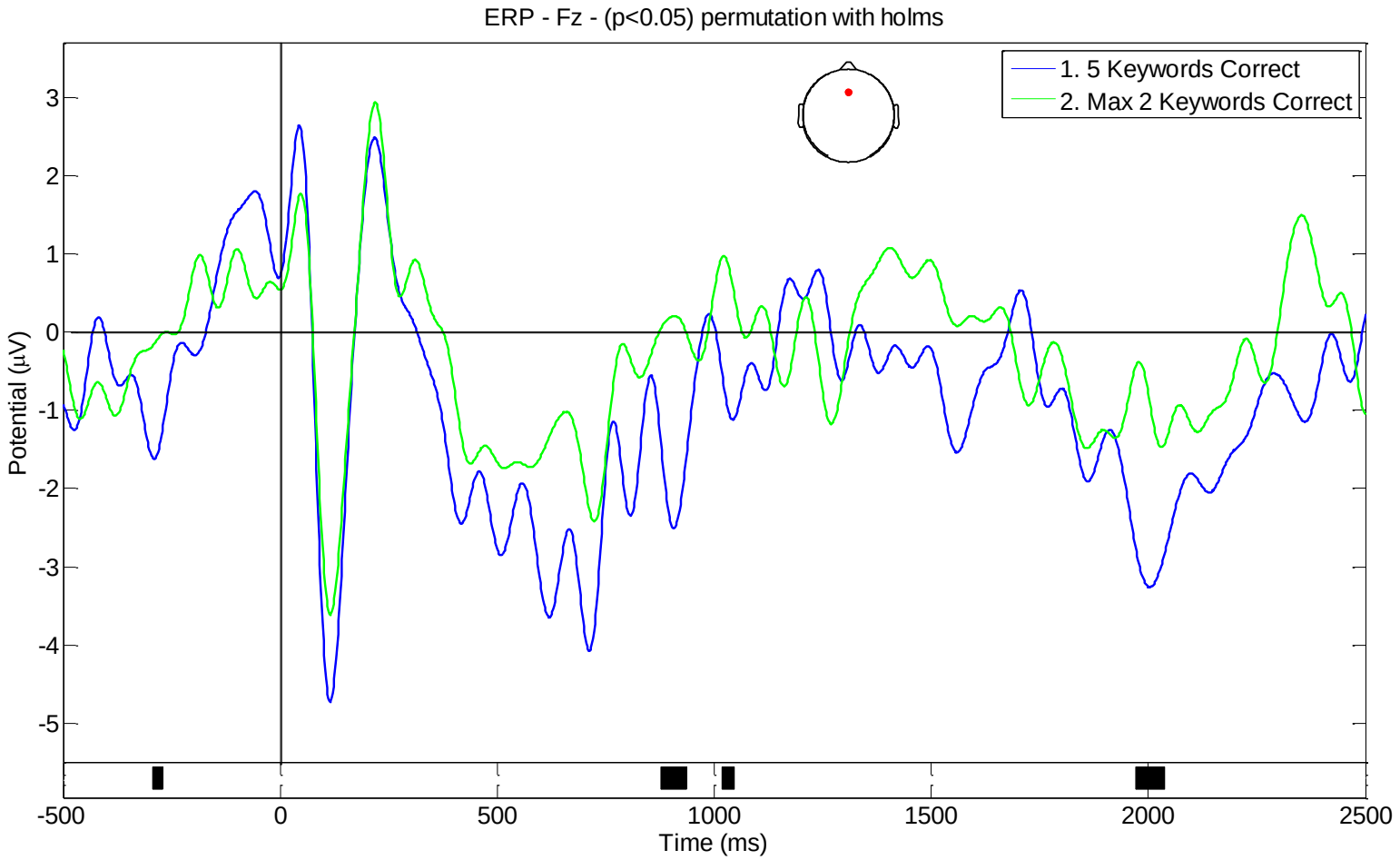

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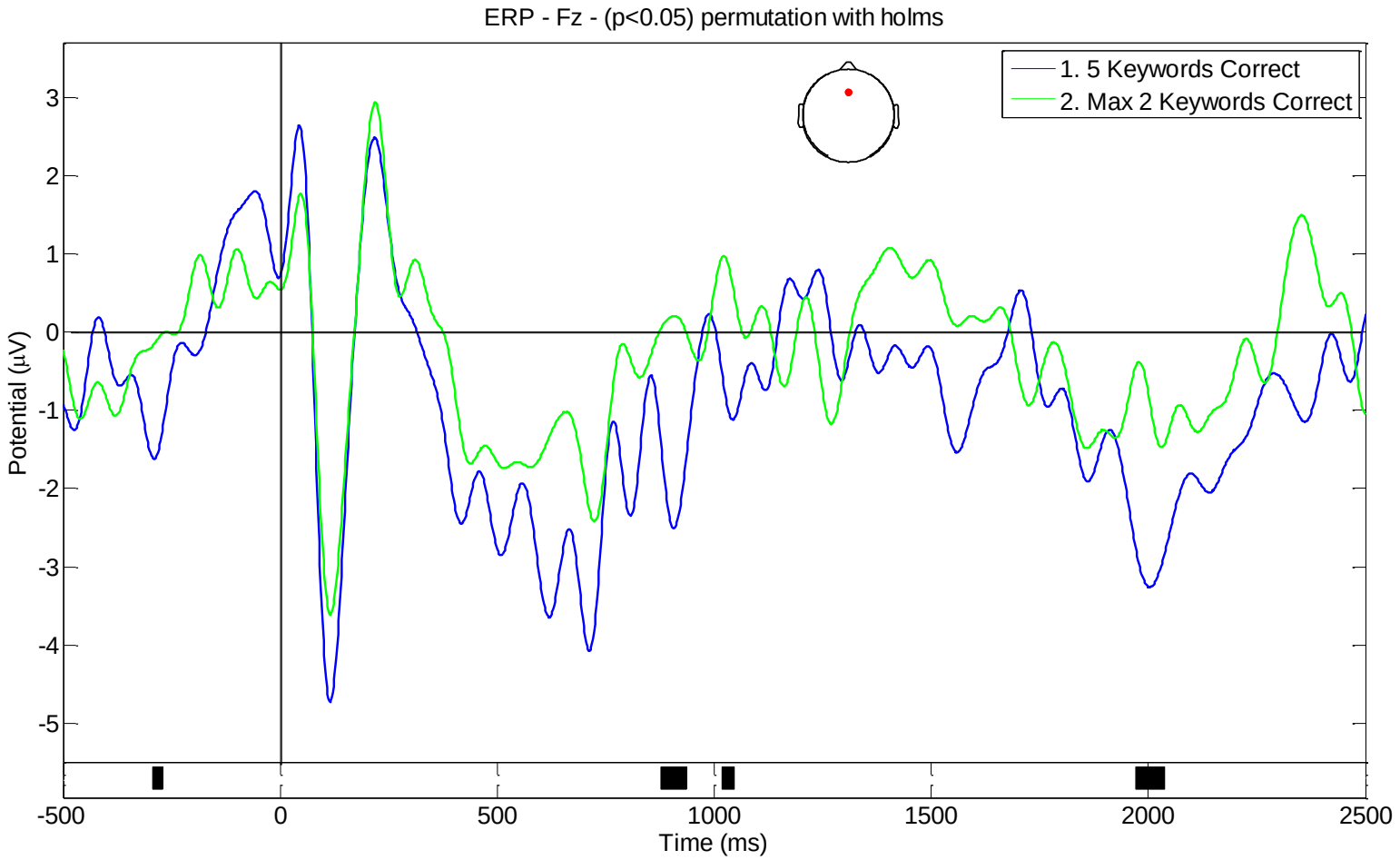

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No acoustic differences between the conditions.

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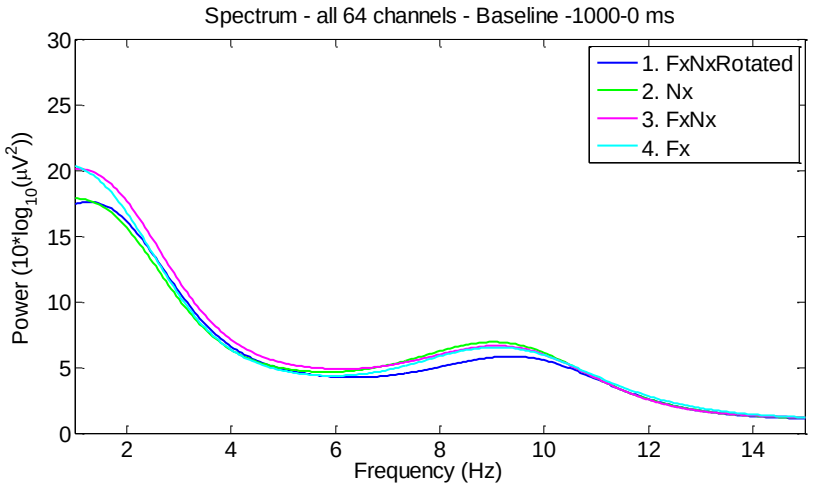
4. EEG power spectra – periodicity



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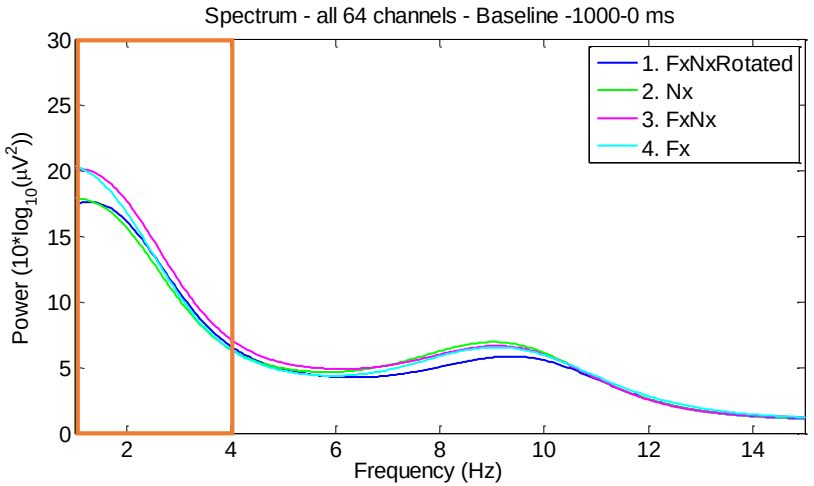

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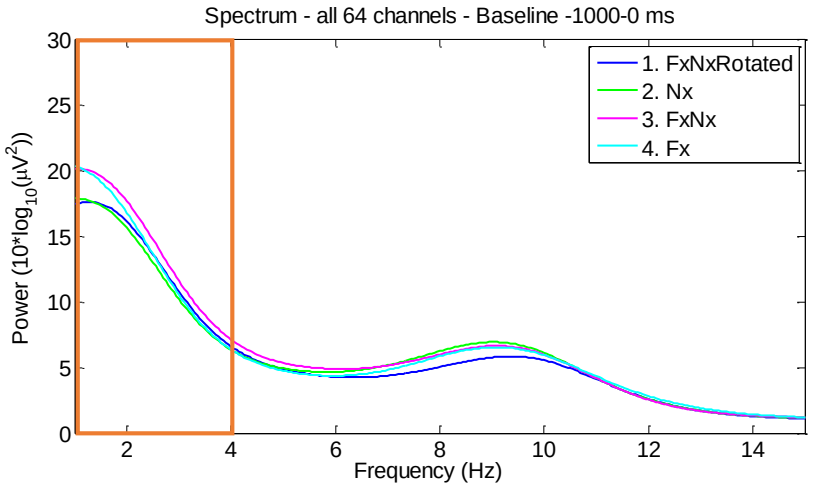

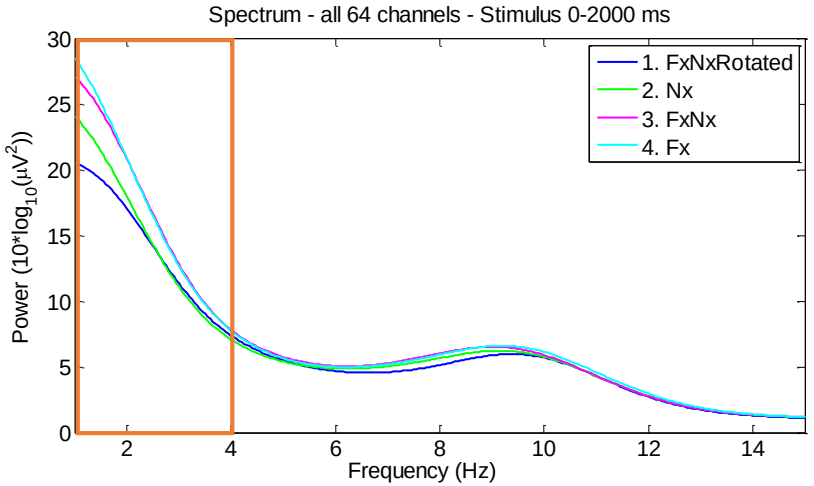

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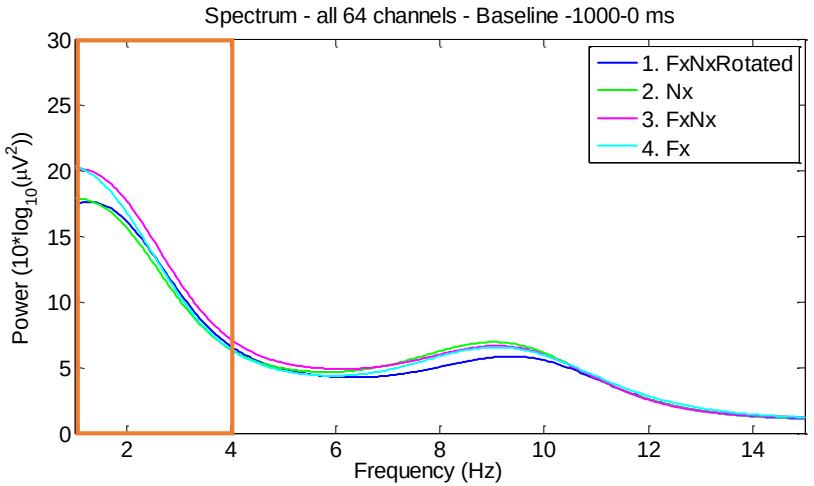

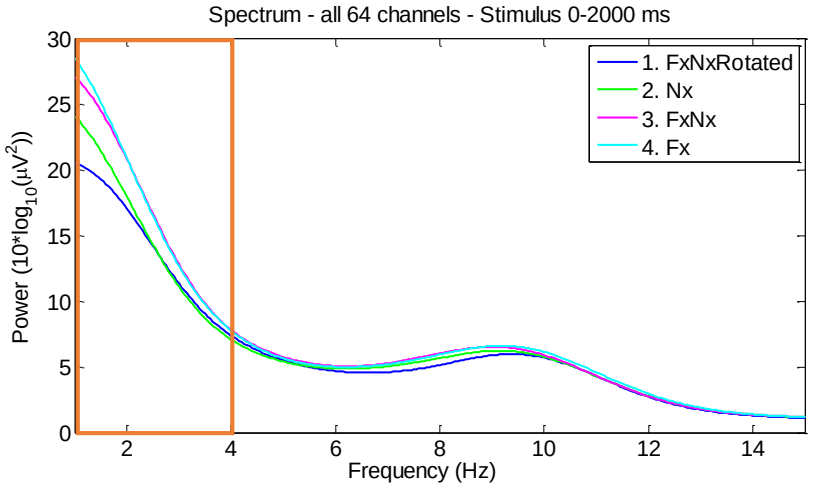

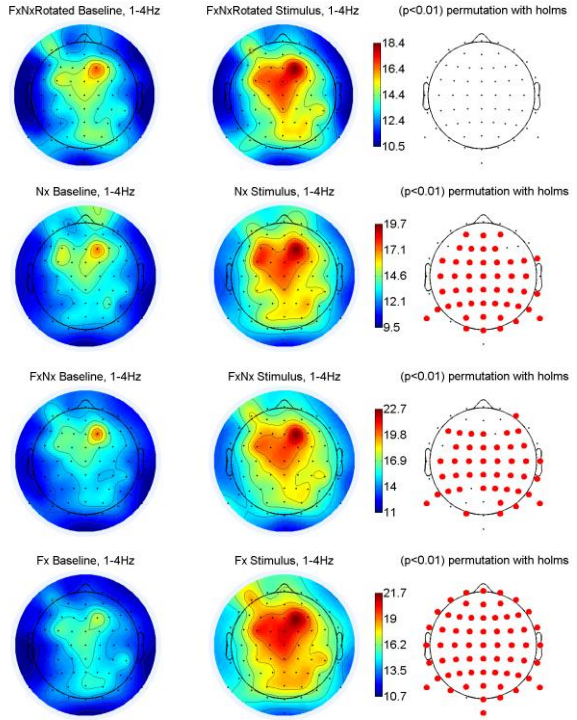

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Statistically significant in all conditions except 'FxNxRotated'.

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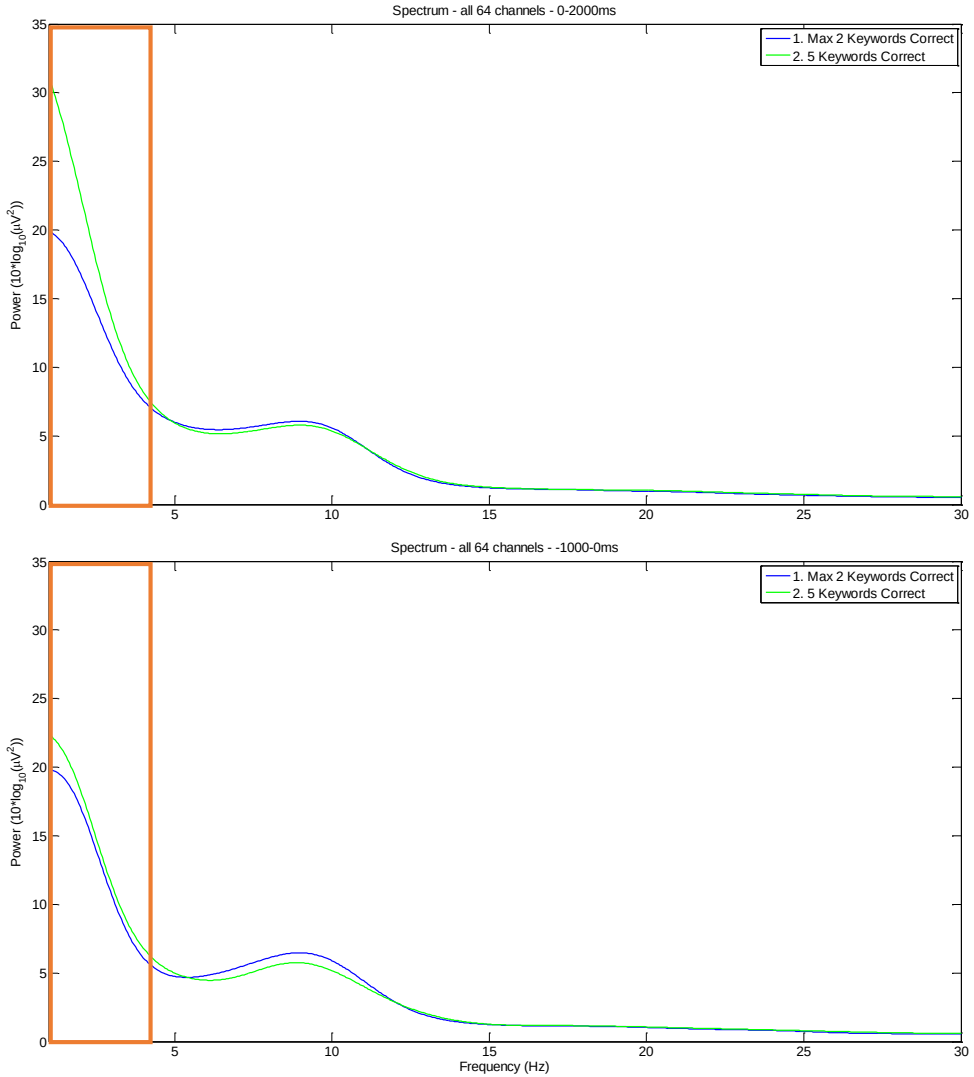

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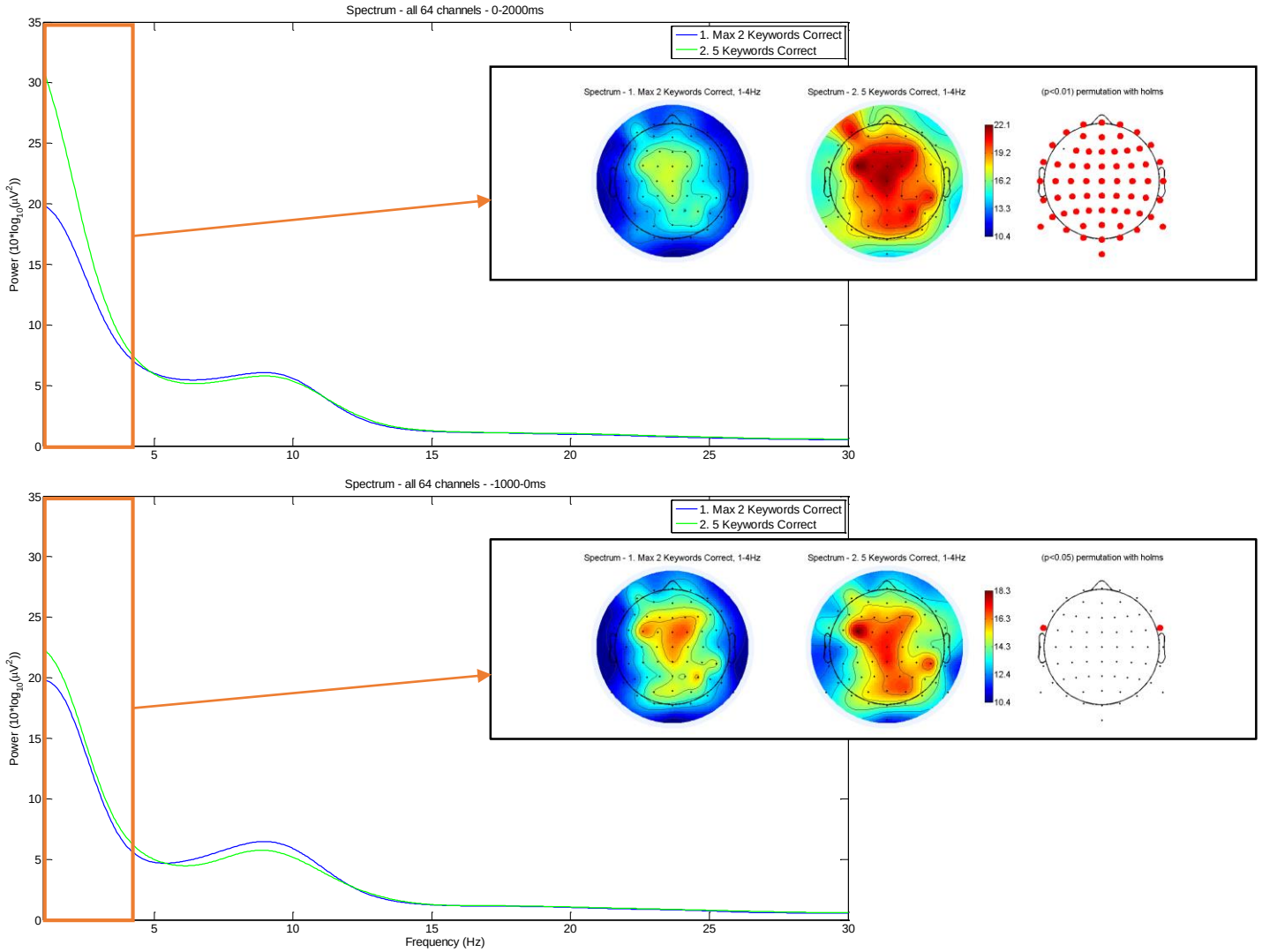
Experiment 4: Cortical EEG and periodicity

5. EEG power spectra – intelligibility



Amplitude differences of the EEG waveforms can again be explained by *differences in delta power* (1–4 Hz).

Experiment 4: Cortical EEG and periodicity

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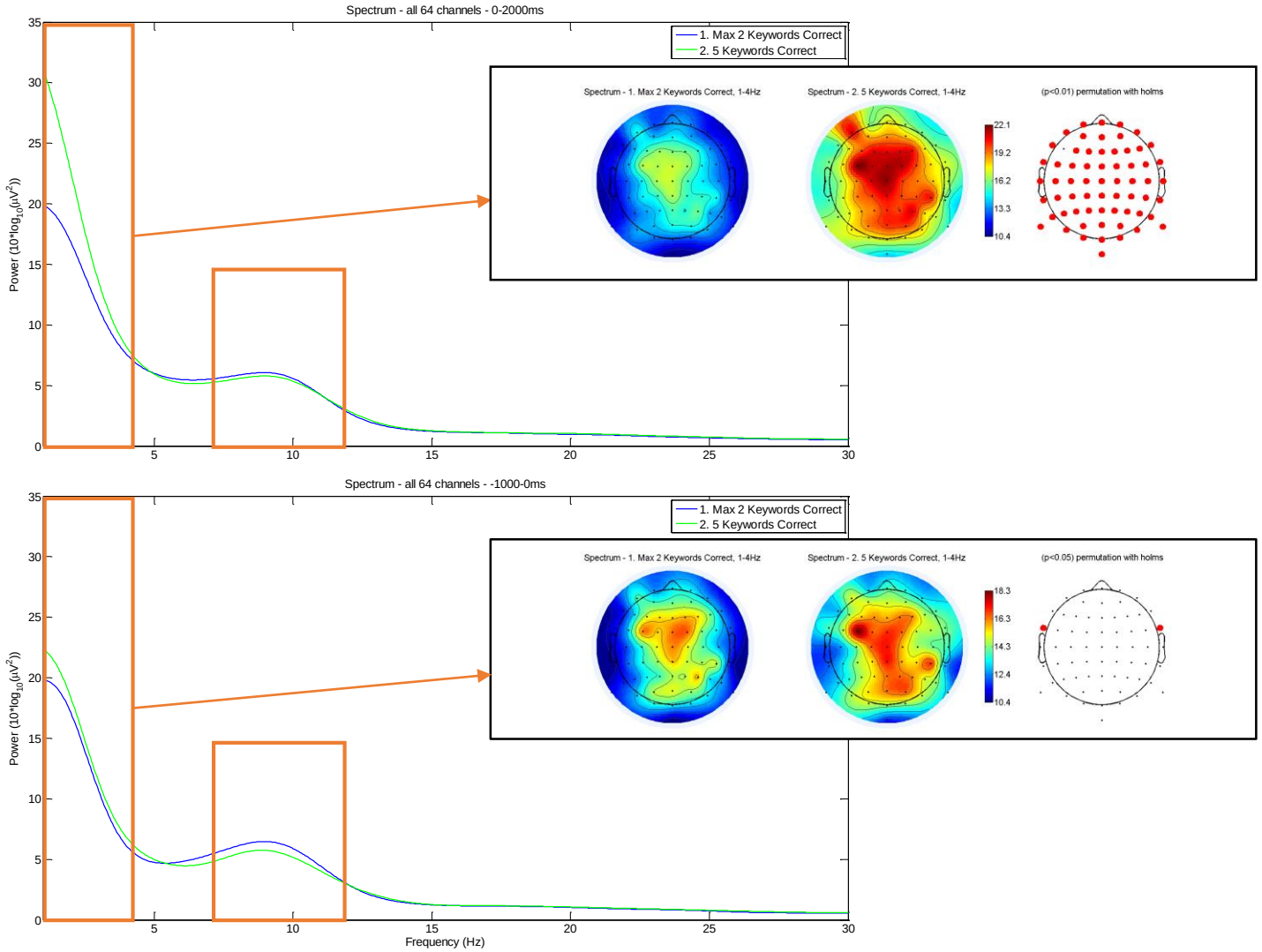

Amplitude differences of the EEG waveforms can again be explained by *differences in delta power* (1–4 Hz).

But there are additional differences in the *alpha range* (7–12 Hz).

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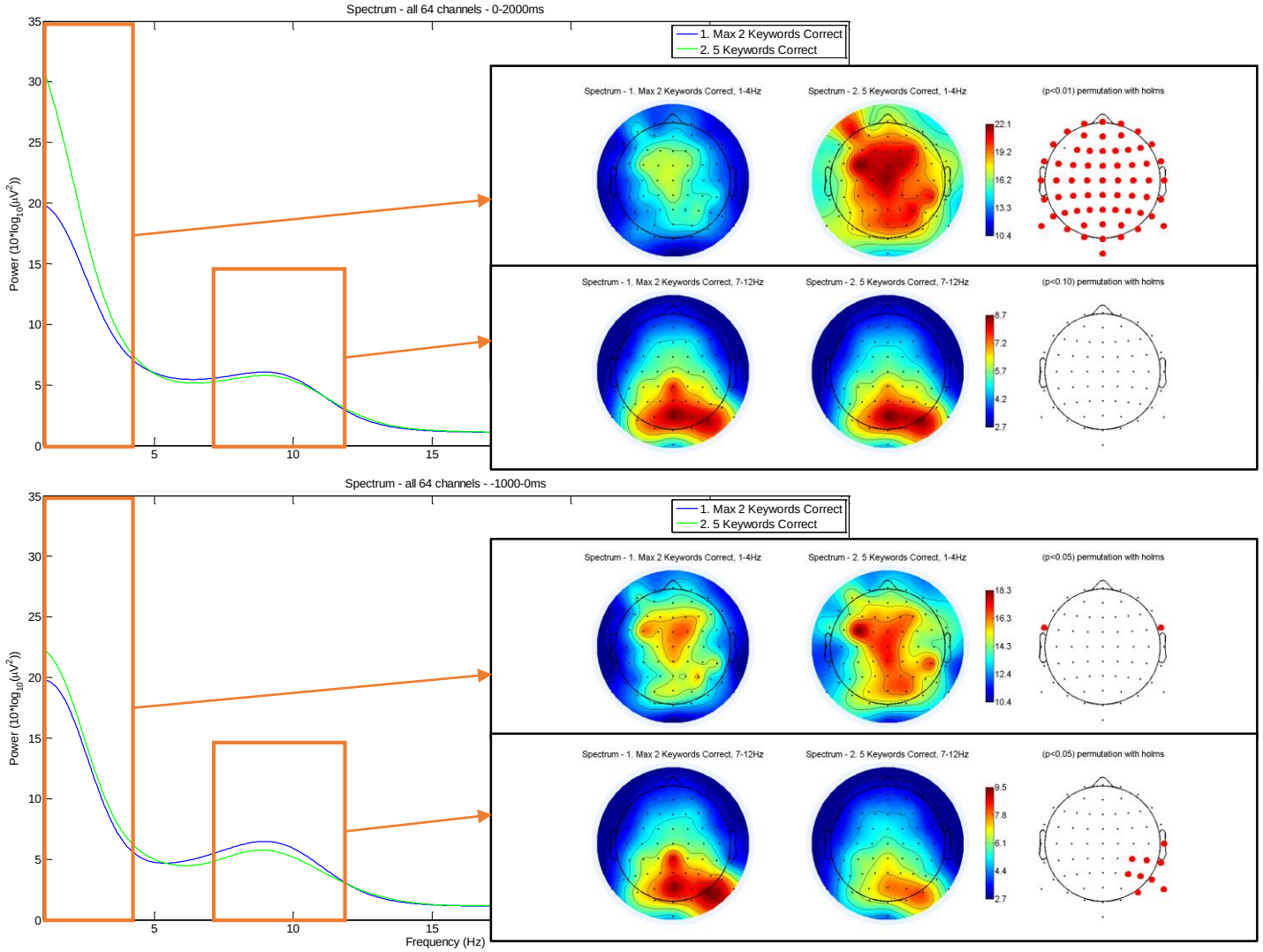


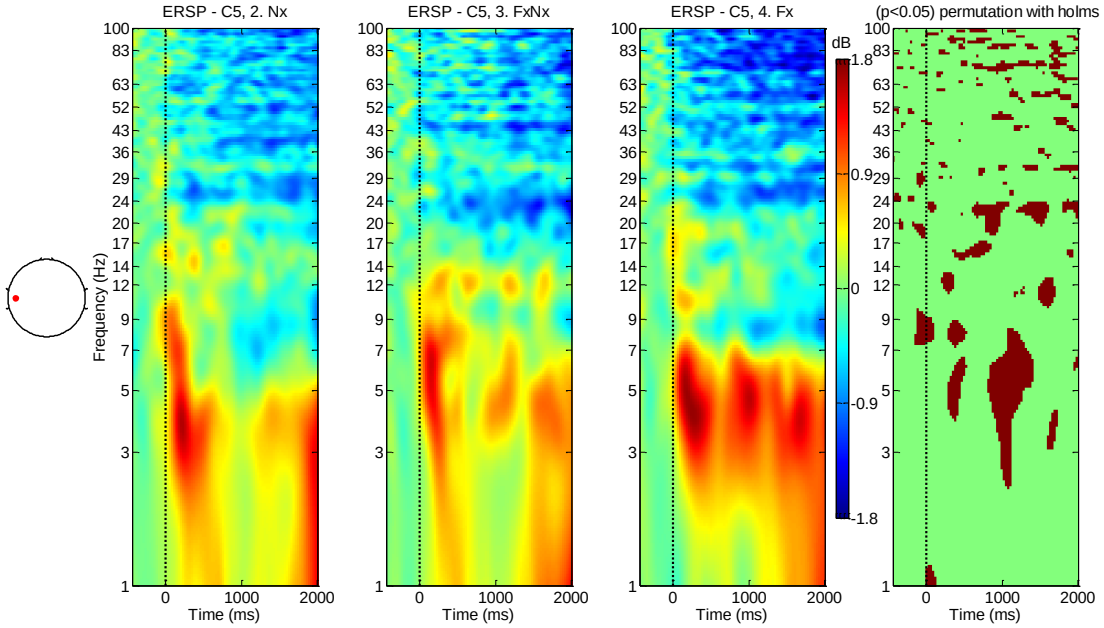
Amplitude differences of the EEG waveforms can again be explained by *differences in delta power* (1–4 Hz).

But there are additional differences in the *alpha range* (7–12 Hz).

Alpha power in the baseline window seems to be a *predictor* of intelligibility.

Experiment 4: Cortical EEG and periodicity

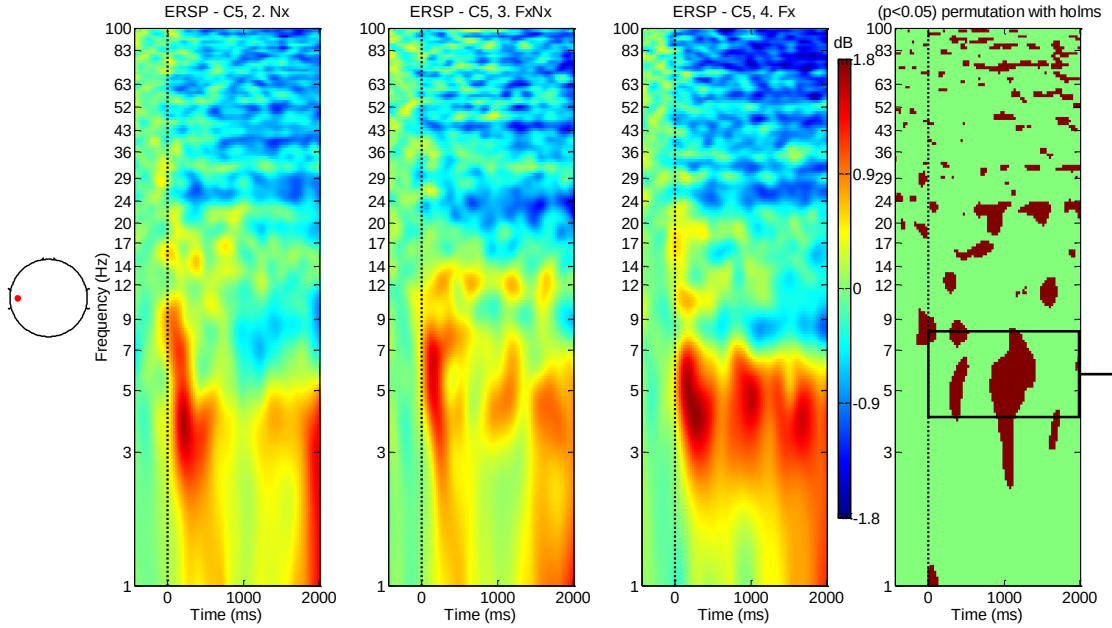
6. EEG oscillation patterns – periodicity

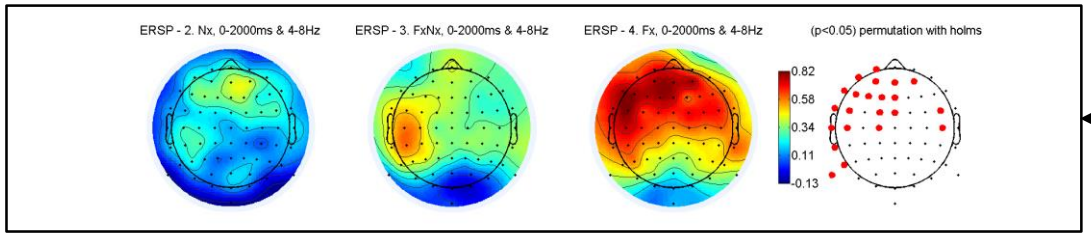


Spectrograms of oscillatory power differences relative to baseline (no ‘FxNxRotated’).

Experiment 4: Cortical EEG and periodicity

6. EEG oscillation patterns – periodicity





Spectrograms of oscillatory power differences relative to baseline.

Pattern differs across frequency with strongest effects in the *theta* (4–8 Hz)

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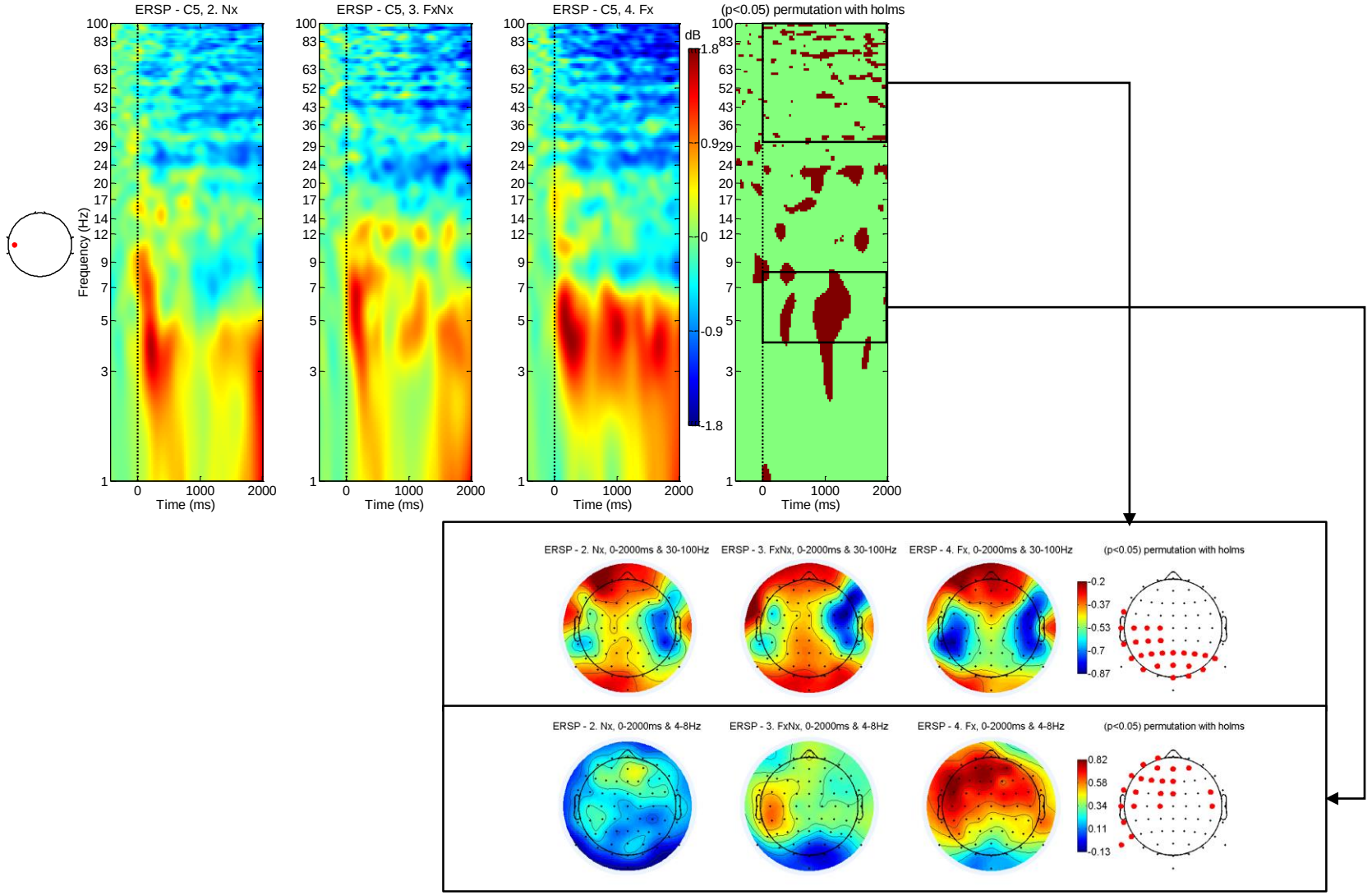
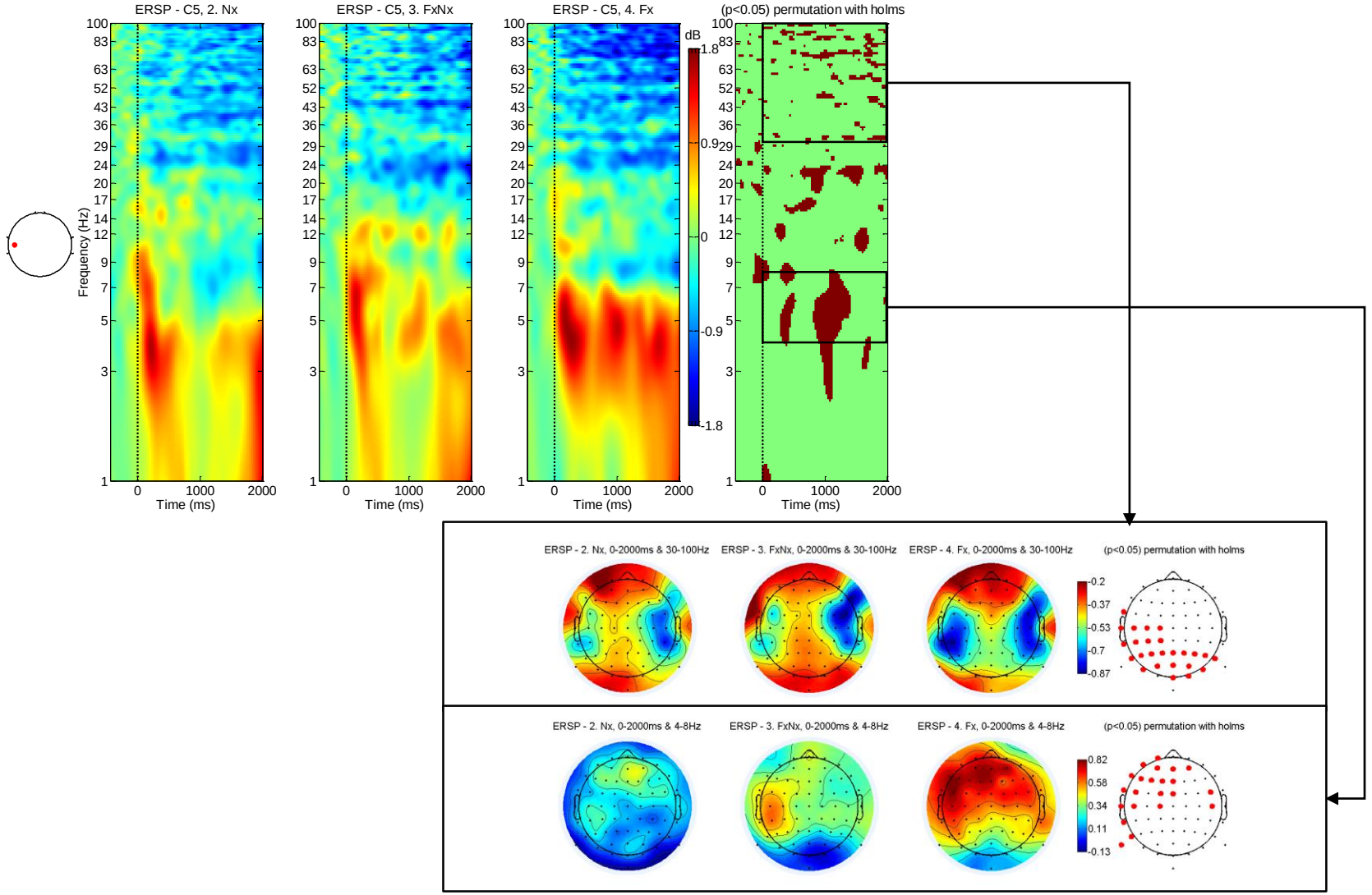


Spectrograms of oscillatory power differences relative to baseline.

Pattern differs across frequency with strongest effects in the *theta* (4–8 Hz) and *gamma* (30–100 Hz) bands.

Experiment 4: Cortical EEG and periodicity

6. EEG oscillation patterns – periodicity



Spectrograms of oscillatory power differences relative to baseline.

Pattern differs across frequency with strongest effects in the *theta* (4–8 Hz) and *gamma* (30–100 Hz) bands.

Fully periodic speech (Fx) strongly differs from other two conditions.

Experiment 4: Cortical EEG and periodicity

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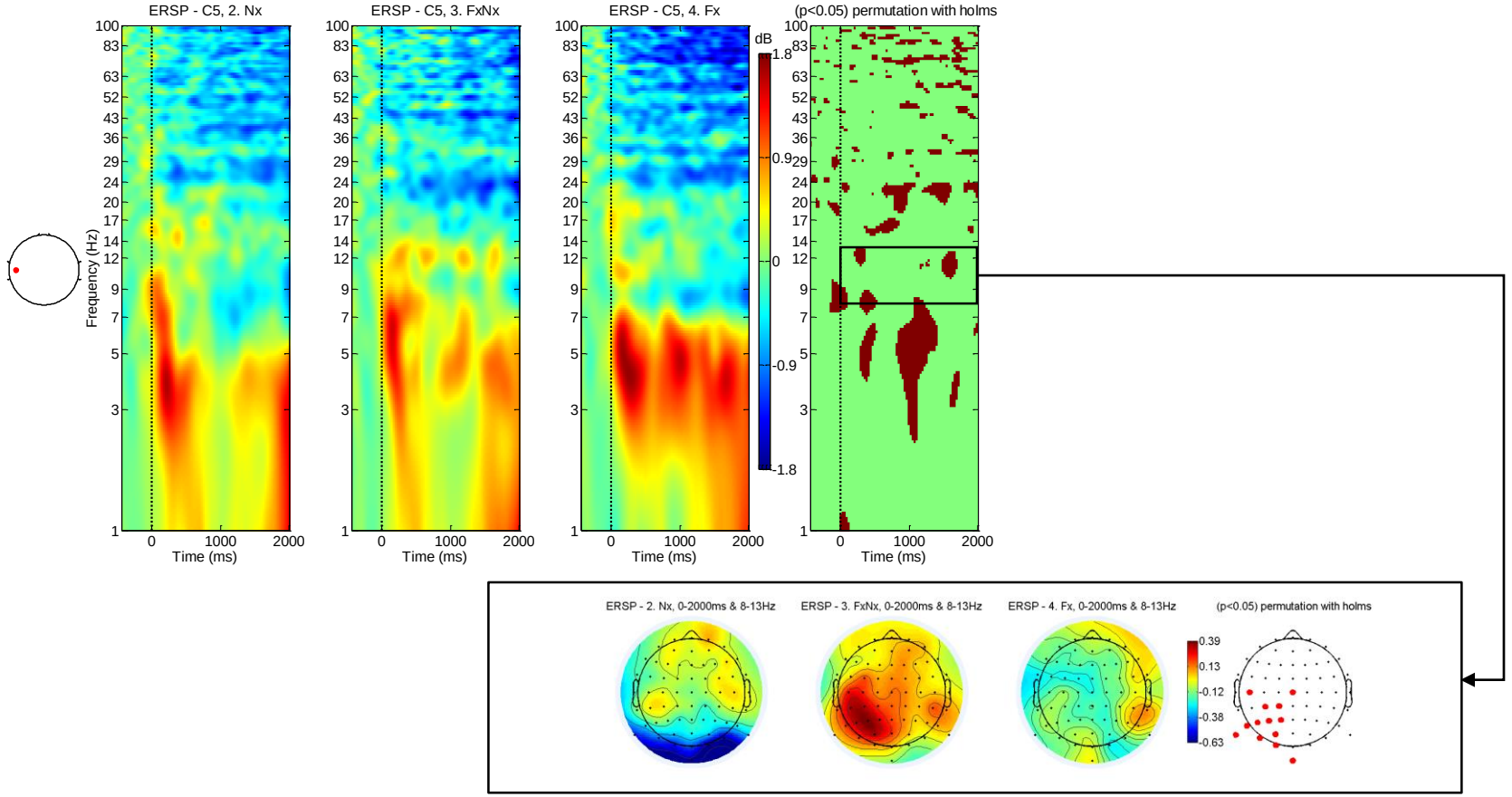
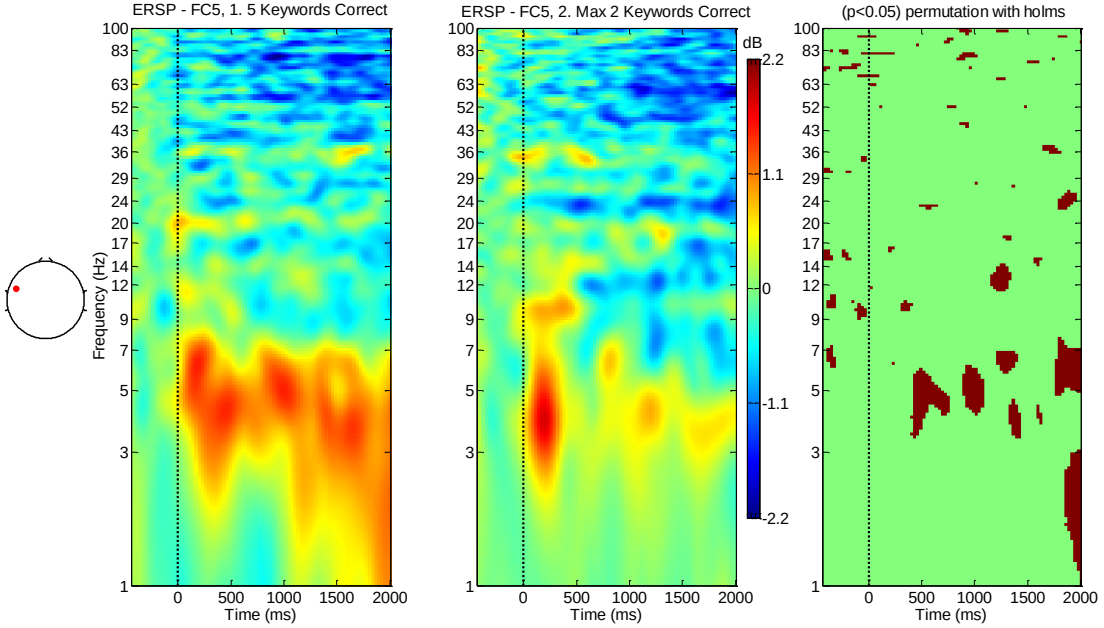


Spectrograms of oscillatory power differences relative to baseline.

Additionally, we found more *alpha* (8–13 Hz) power in the FxNx condition, possibly reflecting *greater ease* of processing.

Experiment 4: Cortical EEG and periodicity

7. EEG oscillation patterns – intelligibility



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Experiment 4: Cortical EEG and periodicity

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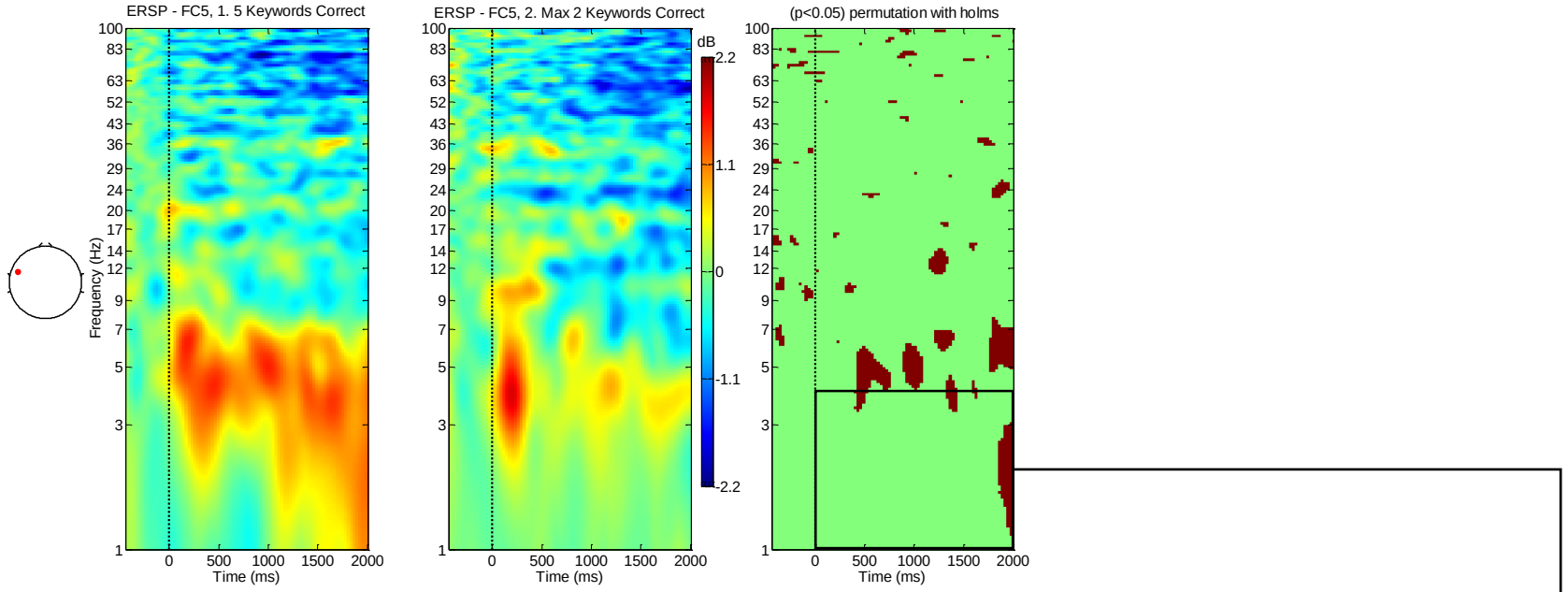

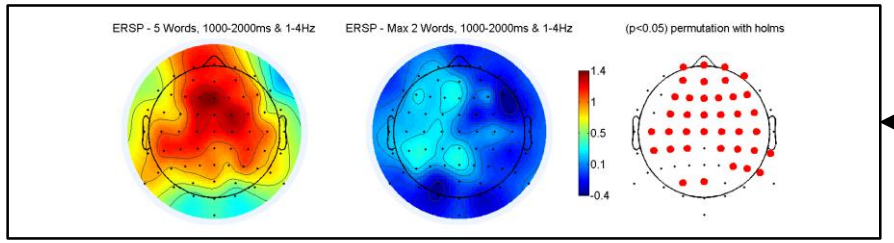

Spectrograms of oscillatory power differences relative to baseline.

Intelligible speech (*Fx*) has more power at lower frequencies (*delta* and *theta*, 1–8 Hz).

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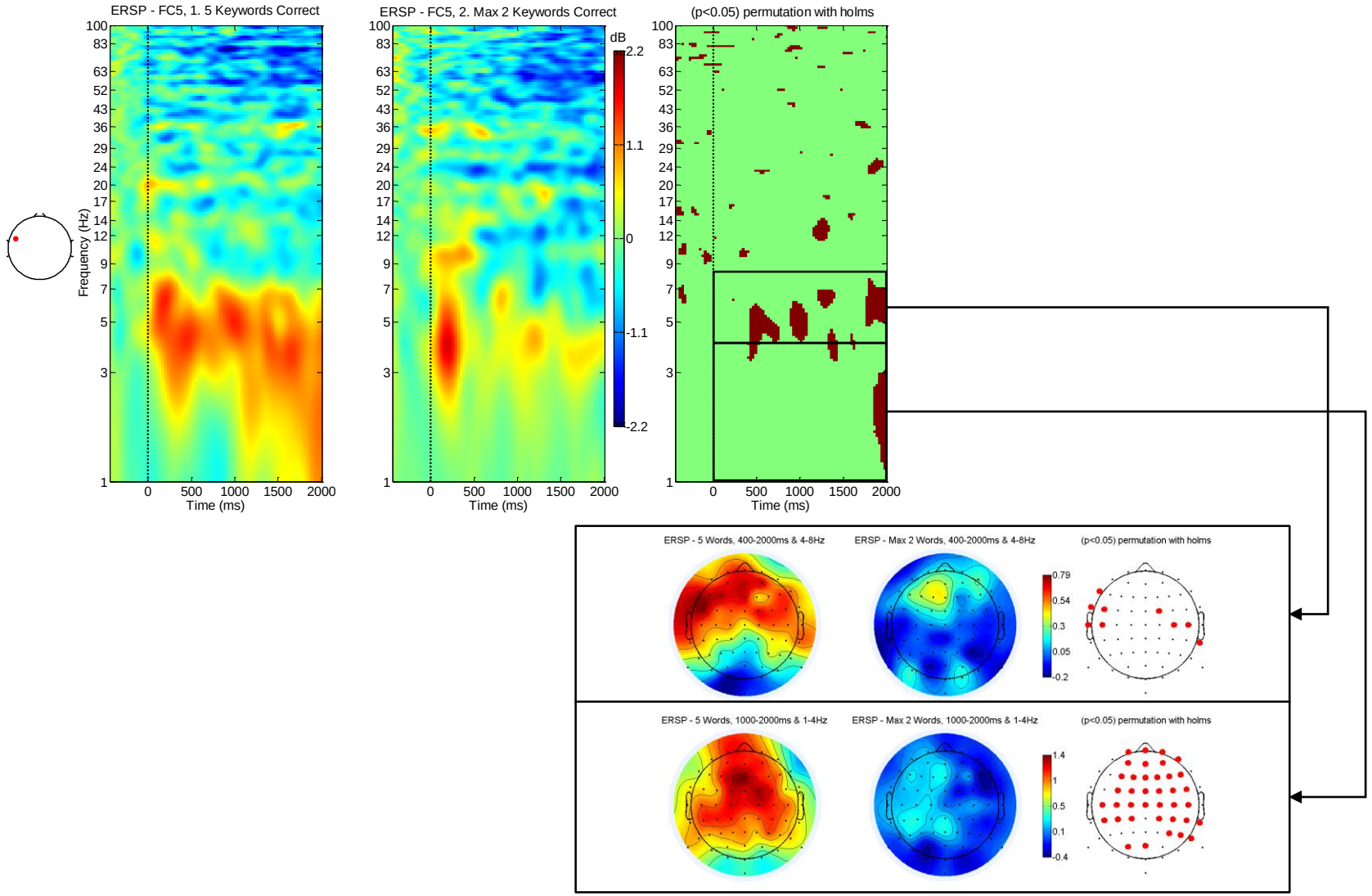

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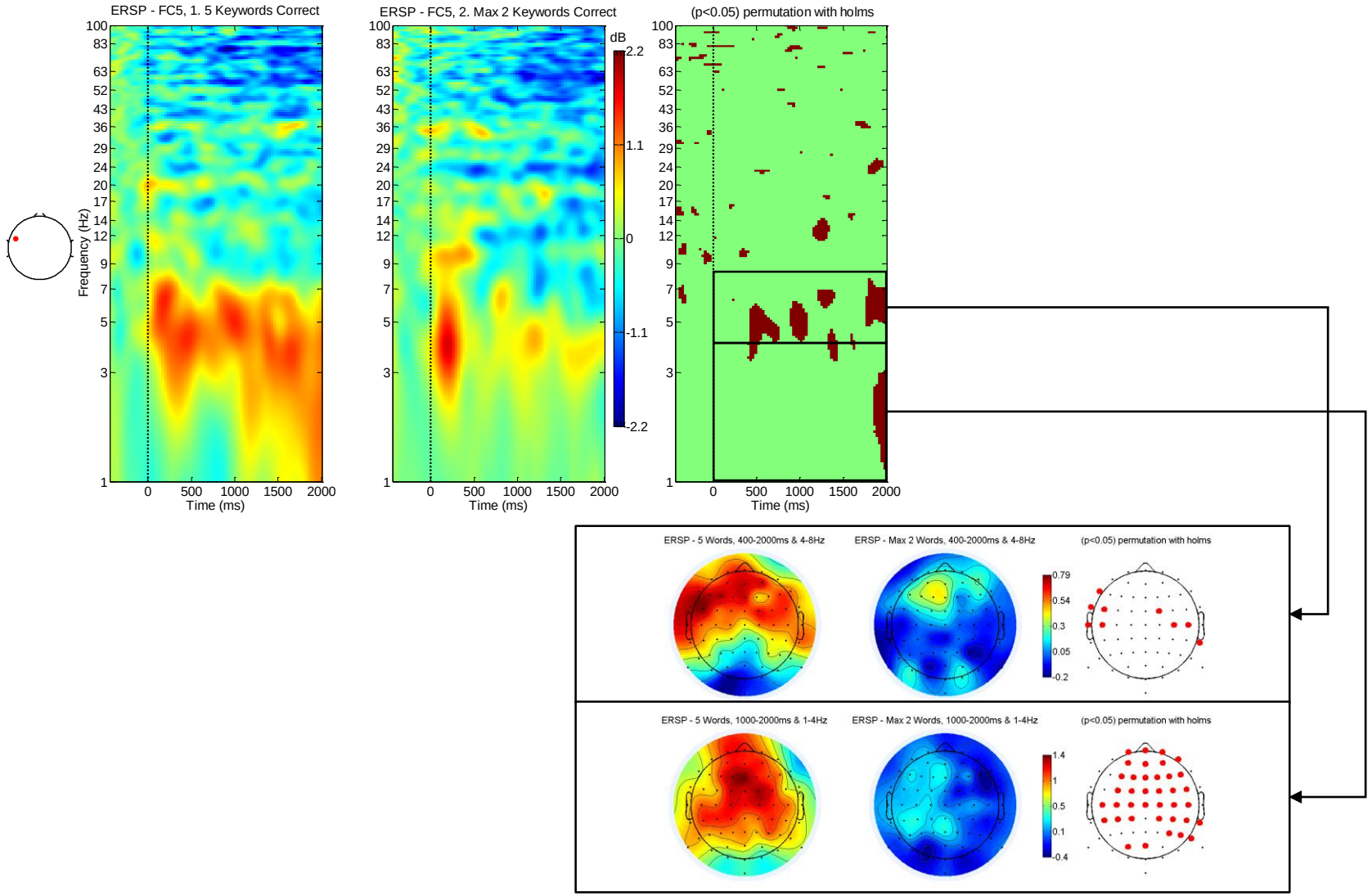

Spectrograms of oscillatory power differences relative to baseline.

Intelligible speech (*Fx*) has more power at lower frequencies (*delta* and *theta*, 1–8 Hz).

No differences in the *alpha* range observed.

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Neural oscillation pattern over time depends on both acoustics *and* intelligibility.