neuromatch

Effect of Visual Noise on High-Gamma ECoG Response Latency in the Fusiform Gyrus During Face Recognition

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Presentation of a 3-week project during Neuromatch summer school “Computational Neurosciences”

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Megapod/Pod: Caspian/Lakshmi

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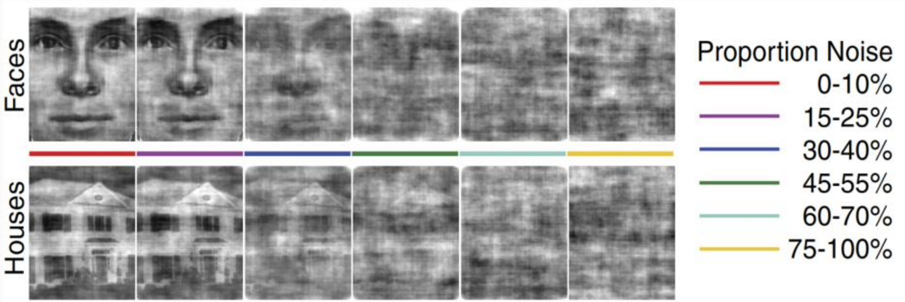
Code: https://github.com/obayalalousi/ecog-noisy-faces-recognition/

RECAP: Meet The Team

Introduction

Dataset:

- **ECoG data**
- **7 epileptic patients**
- Miller et al. (2017).
- Electrodes in **face-selective regions**
- Images of **faces** (315 images) **and houses** (315 images) with **different levels of added noise**
    - Each image was presented during **one second**
- **If an image is thought to be a face,** the **subject presses a key**



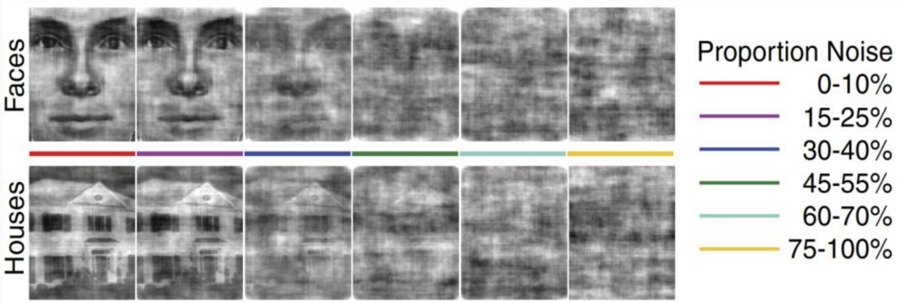
Miller et al. (2017)

Background

Persistent activity in fusiform gyrus despite visual noise in faces (Miller et al., 2017)

More visual noise = slower image identification (Kwon et al., 2016)

Suggests that brain compensates: probably performing inference at the cost of processing time



Miller et al. (2017)

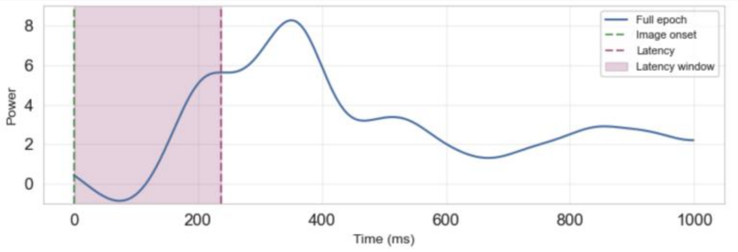
Hypothesis

In the **fusiform gyrus**, for **high gamma-band** power activity:

We hypothesize a **positive correlation** between:

- ➢ **Noise level** in **recognized** visual **face images** & **latency to reach the first peak**

No noise



Noisy image

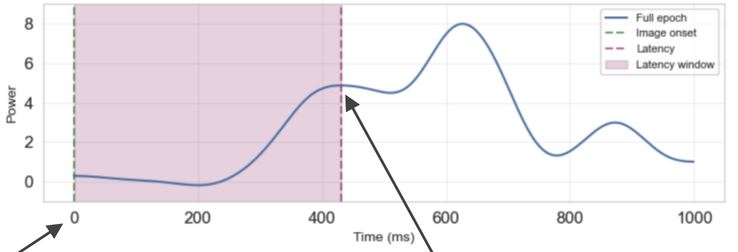
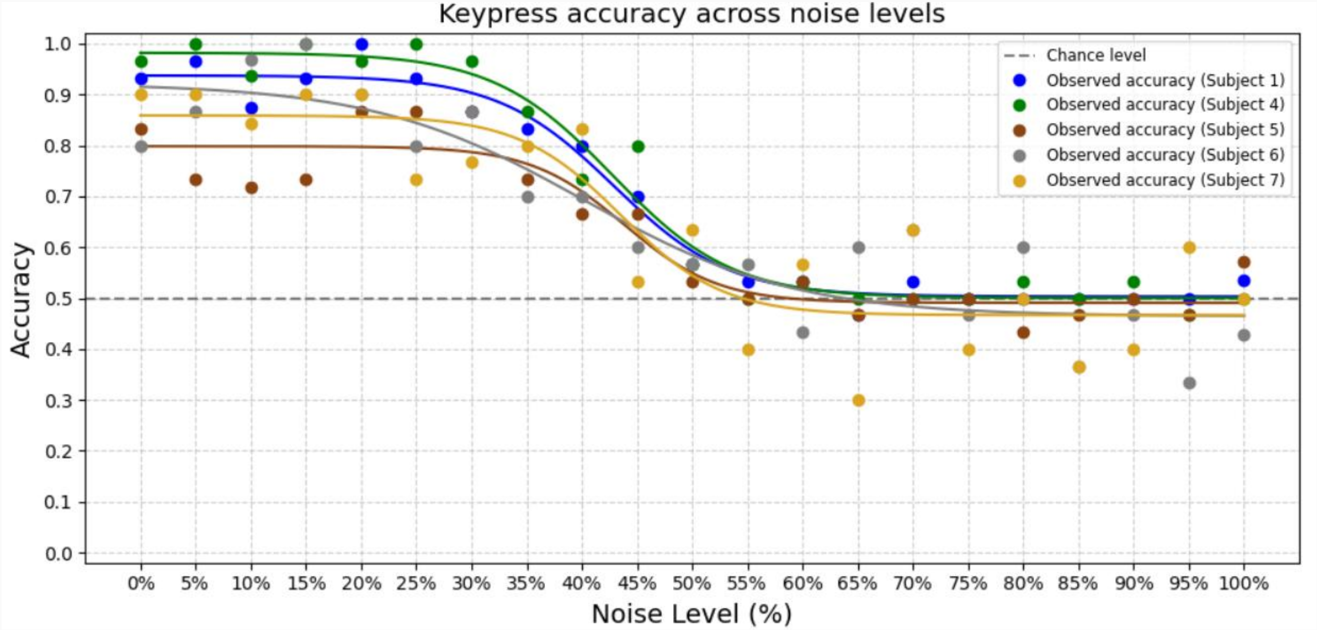


Image onset on the screen

First peak of the high gamma band power

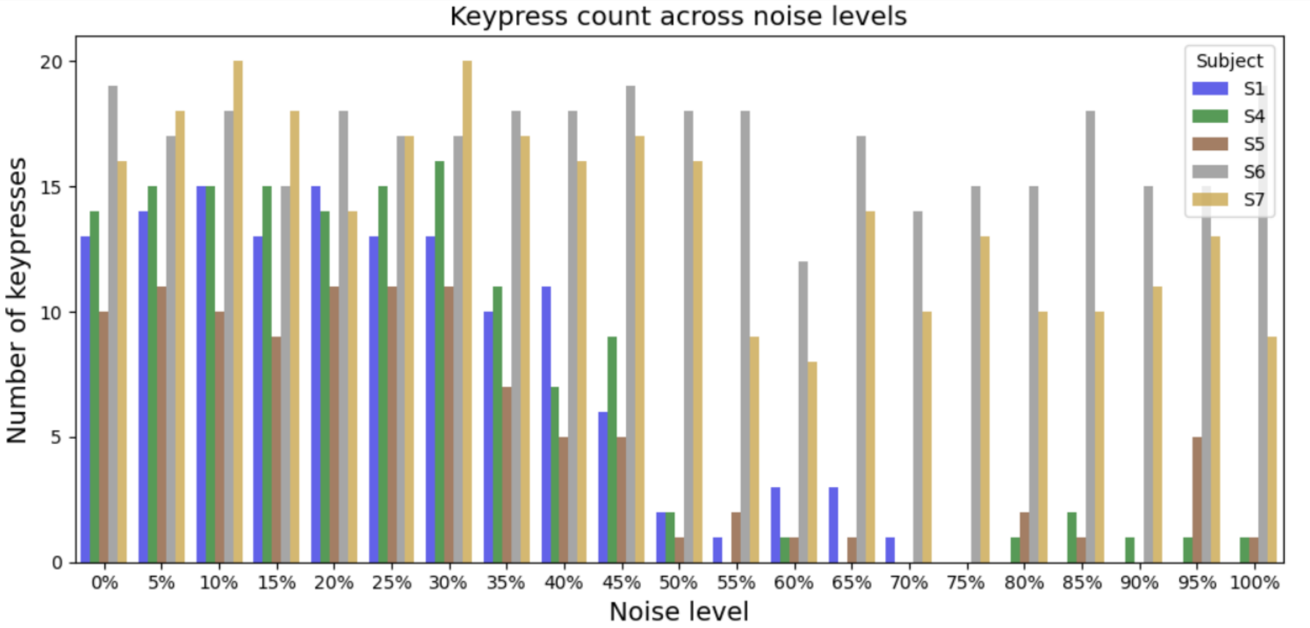
Subject Behavior



Subjects 2 and 3 did not have a keypresser and were excluded from our analysis, as their data cannot address our question.

Keypress accuracy across subjects approaches chance level (~50%) from around 50–55% noise onward.

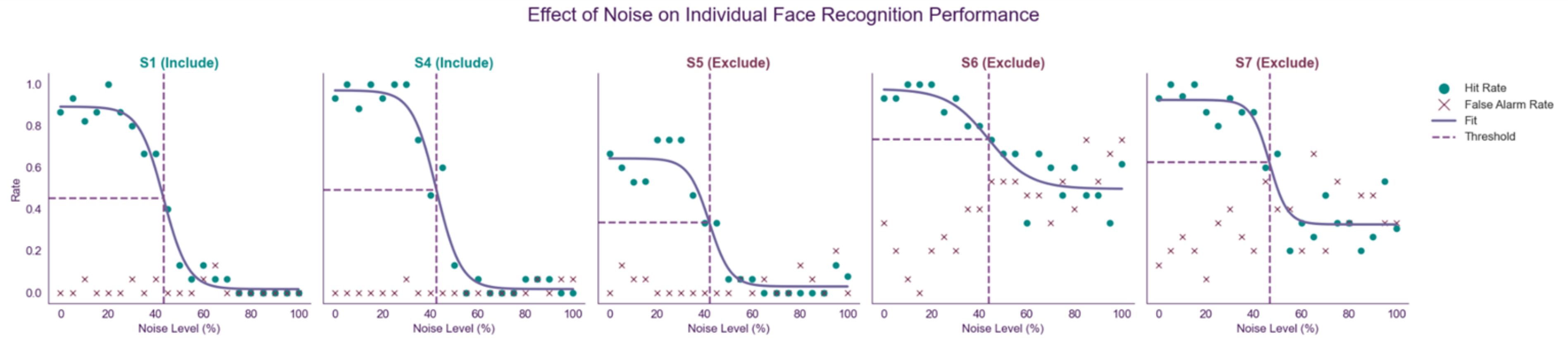
Subject Behavior



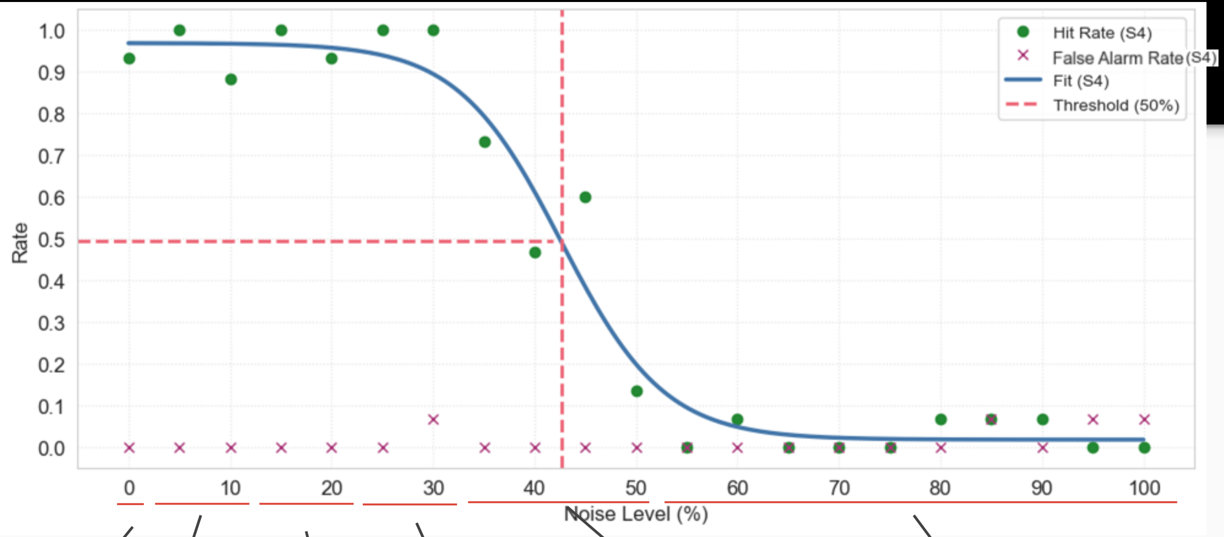
- **At high noise levels**, Subjects 6 and 7 tend to press the key frequently, but their accuracy does not exceed chance level. Their behavior is therefore considered less reliable under high noise.
- **At low noise levels**, Subject 5 shows relatively bad accuracy, even in the absence of noise. Their behavior is considered less reliable under low noise.

Therefore, our analysis is restricted to Subjects 1 and 4, who demonstrate the most reliable keypress behavior.

Subject Behavior



Subject 4 Analysis



Only correctly identified faces with noise level up to 50% were included in analysis

No Noise:
14 identified faces (14 epochs were included in analysis)

5-10% noise category:
30 identified faces

15-20% noise category :
29 identified faces

25-30% noise category :
30 identified faces

35-50% noise category :
29 identified faces

55-100% noise category:
4 identified faces

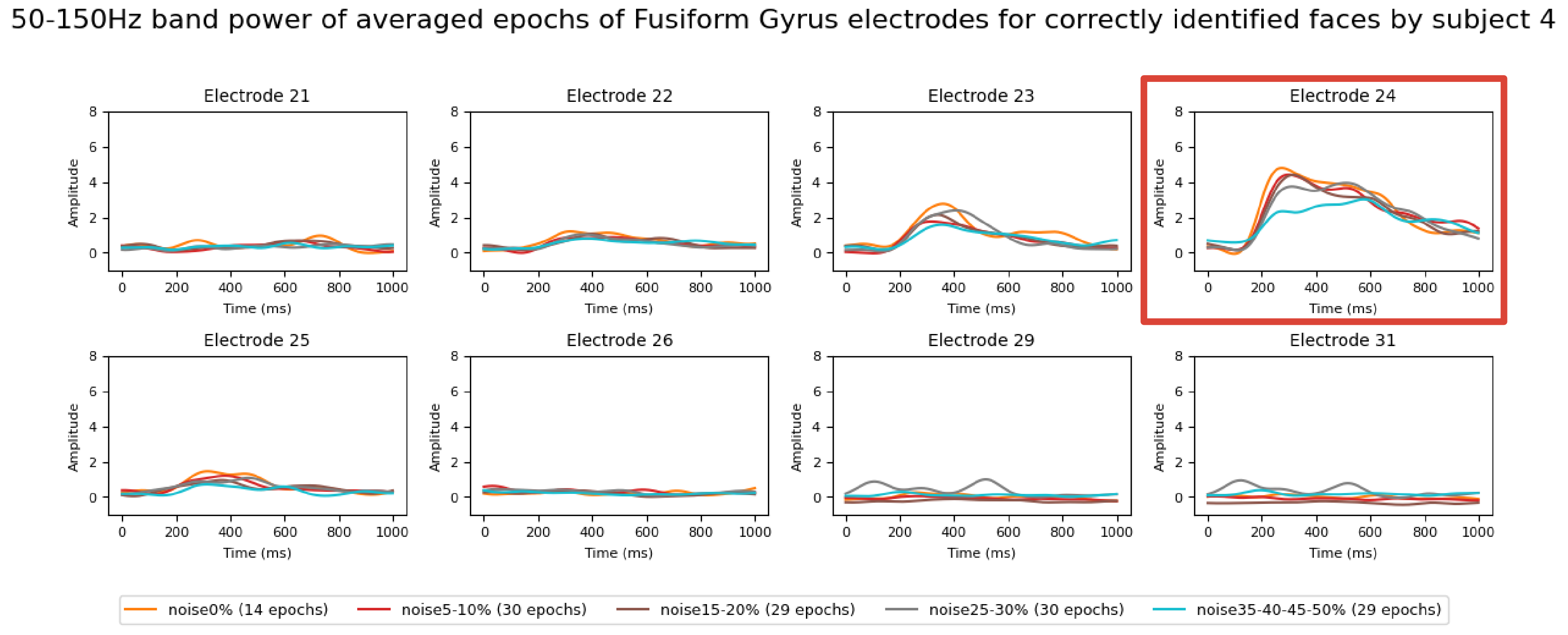
Not enough data : discarded from analysis

Power-time analysis

Raw voltage data processing steps :

- Ambient line noise suppression (notch-filtered at 60, 120, 180, 240 and 250Hz).
- Z-score across time.
- Bandpass Filtering : extraction of the **high-gamma band (50-150 Hz**) using a 3rd-order Butterworth filter.
- Common Averaging Referencing (CAR)
- Power Computation (Squaring of the filtered signal)
- Power Smoothing (5 Hz low-pass filtering)
- Baseline (no stimulus) mean subtracting
- Normalization (division by baseline mean)
- Epoch Extraction : **from image onset to image offset (1000 ms)**

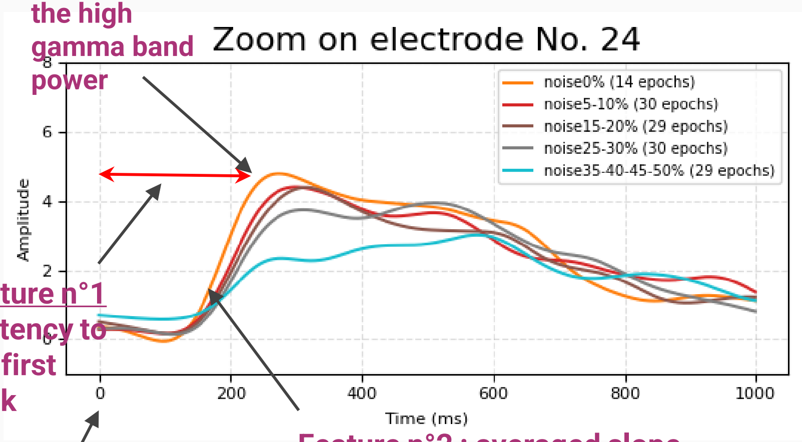
Power-time analysis



Epochs are considered from image onset (t=0) to image offset (t=1000 ms)

Feature selection of power-time curves

First peak of the high gamma band power



Feature n°1 : Latency to the first peak

Image onset on the screen

Feature n°2 : averaged slope over all timepoints of the rising edge of the first peak

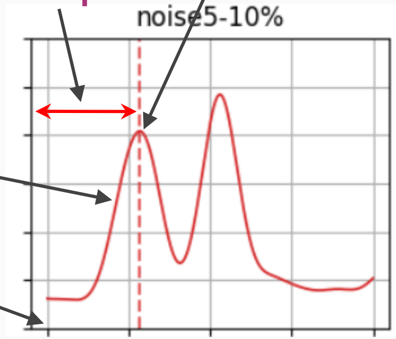
Averaged power of high-gamma band **over all epochs** of each noise category

Feature n°1 : Latency to the first peak

First peak of the high gamma band power

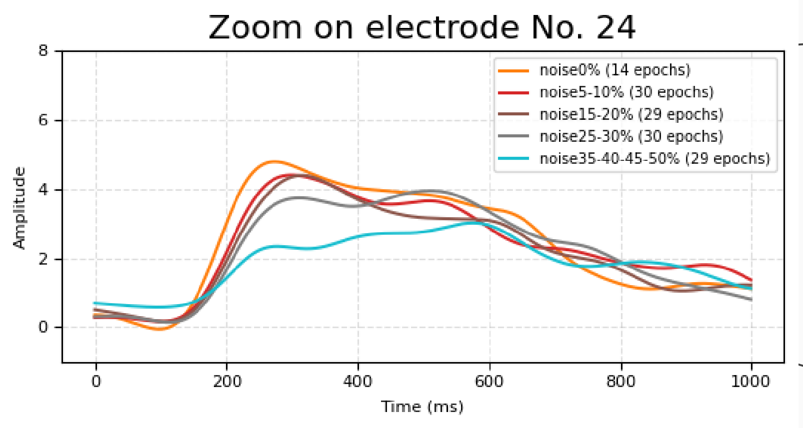
Feature n°2 : averaged slope over all timepoints of the rising edge of the first peak

Image onset on the screen



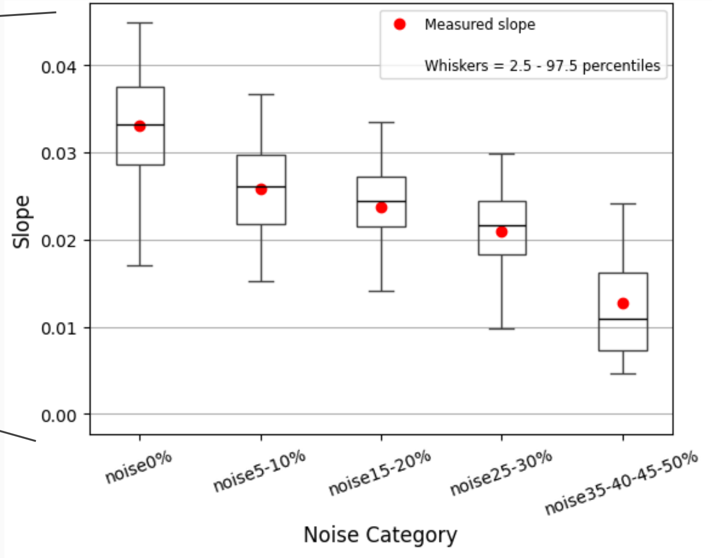
Power of high-gamma band **over each individual epoch** of each noise category

1) Slope analysis of the rising edge of the first peak



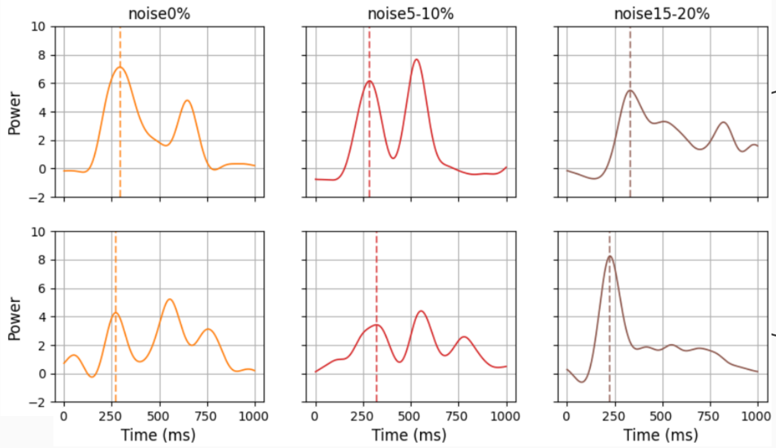
Mean slope obtained for **averaged power** epochs of each noise category

First peak mean slope of the averaged event-related high-gamma band power (Subject 4, Electrode 24)

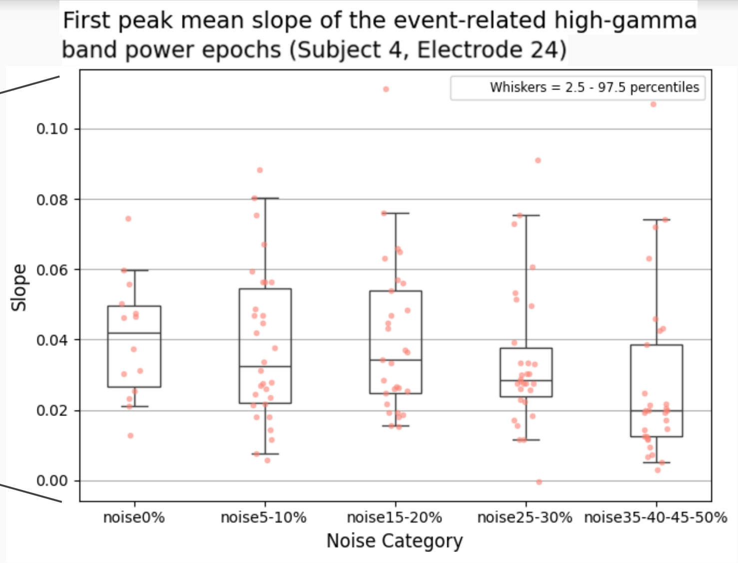


CI95% obtained over 10 000 bootstraps

1) Slope analysis of the rising edge of the first peak

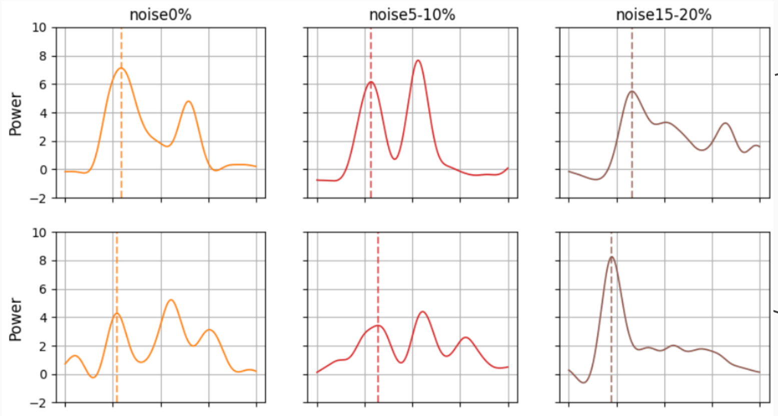


Mean slope obtained **for each individual epoch** of each noise category

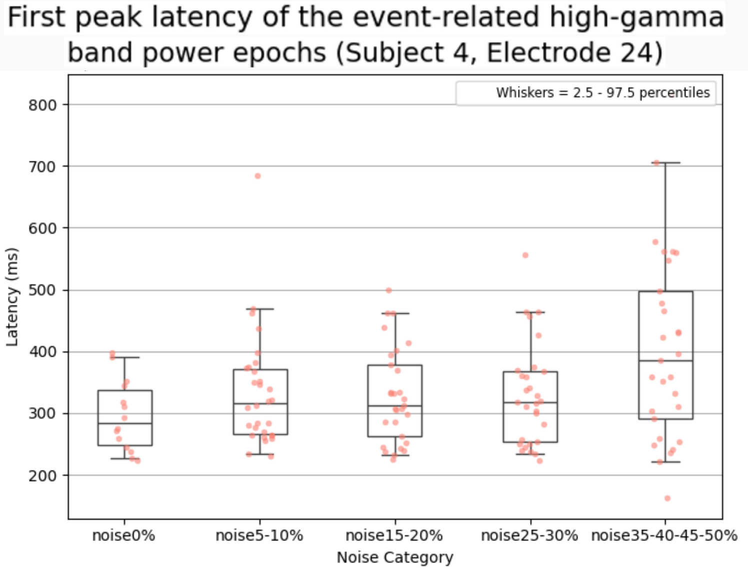


Permutation test (1000 permutations) with Spearman correlation
Negative correlation (ρ = -0.268)
p-value = 0.003 (**)

2) Latency analysis of the first peak



Latency to the first peak obtained **for each epoch**



Permutation test (1000 permutations) with Spearman correlation
Positive correlation (ρ = 0.200)
p-value = 0.017 (*)

Reproducibility

Similar results were observed for Subject 1 and electrode 36 (fusiform gyrus)

Relationship	Direction	Spearman's ρ	p-value	Interpretation
Noise level vs. First peak slope	-ve	-0.313	< 0.001 (***)	Significant negative correlation
Noise level vs. First peak latency	+ve	0.148	0.096 (ns)	Marginal positive trend

Discussion

In the fusiform gyrus:

1. **Higher face images noise (while still recognizable) is associated with a reduced slope of first high-gamma peak.**
    - Significant negative correlation
    - Indicating a deceleration in power increase as noise levels rise.

2. **Higher face images noise (while still recognizable) is associated with increased latency of first high-gamma peak.**
    - Significant positive correlation in one subject and a similar non-significant trend in the other.

These findings suggest a compensatory mechanism in the brain that preserves face perception under noisy conditions at the cost of processing speed.

Future implications

Expand analysis:

- Robust regression models
- Consider alternative features for modeling

Address limits:

- Peak detection robustness
- Single-trial signal variability → **LFDA** for noise reduction