**Cable evaluation**

1. Objective:  
   Evaluate whether a thicker or thinner cable provides better EEG signal quality, comparing electrodes FP1 (thick cable) and FP2 (thin cable) across two conditions: eyes open (EO) and eyes closed (EC).

### Protocol:

* Two spiky dry electrodes were positioned simultaneously at FP1 and FP2.
* FP1 used a regular 26 AWG cable, while FP2 used a thinner 28 AWG cable.
* Reference electrodes were connected using 26 AWG cables and spiky electrodes.
* Three recordings were taken for each condition (eyes closed and eyes open), each lasting 40 seconds.

### Procedure:

1. **Impedance Check:**  
   Using OpenBCI, impedances for both FP1 and FP2 electrodes were monitored and found to oscillate around 300 kΩ.

A table with numbers and symbols

AI-generated content may be incorrect.

1. **Recordings:**  
   Three recordings were made for each condition (eyes closed and eyes open), each lasting 30 seconds. The first 3 seconds of each recording were excluded to avoid artifacts caused by the delay in closing the eyes (as the recording was self-administered).
2. **Data Analysis:**  
   Visual inspection of the recorded signals was performed.

### Results Summary

**Visual inspection**

* The plotted signals showed similar performances for both electrodes

**Signal-to-Noise Ratios (SNR)**

* Across all frequency bands (delta, theta, alpha, beta) and conditions, the thin cable (FP2) consistently showed higher signal-to-noise ratios compared to the thick cable (FP1).
* This suggests that the thinner cable may transmit EEG signals with better relative quality and noise attenuation.

A graph with blue and orange lines

AI-generated content may be incorrect.A graph of a sound wave

AI-generated content may be incorrect.

**Power Metrics**

* The thin cable yielded higher absolute power in alpha, beta, and delta bands during both eyes-open and eyes-closed conditions, indicating stronger EEG signal capture.
* Although line noise power was slightly higher with the thin cable, the overall increase in signal power was proportionally greater, leading to improved SNR.

A graph with lines and numbers

AI-generated content may be incorrect.A graph of a graph showing the number of frequency

AI-generated content may be incorrect.

**Signal Quality Indicators**

* Metrics such as zero crossings per second, percentage of flatlines, and large jumps were very similar between cables, indicating low artifact presence and reliable recordings in both cases.
* Amplitude range was wider for the thin cable, supporting stronger signal acquisition.

|  |  |
| --- | --- |
| EOFP1 | EOFP2 |
| alpha\_power\_uV2 81.21  beta\_power\_uV2 270.01  delta\_power\_uV2 117.31  line\_noise\_power\_uV2 68.20  zero\_crossings\_per\_sec 57.61  percentage\_flatline 0.00  large\_jumps 0.00  range\_uV 172.59  symmetry\_corr\_LR 0.88  dtype: float64 | alpha\_power\_uV2 101.96  beta\_power\_uV2 332.11  delta\_power\_uV2 241.12  line\_noise\_power\_uV2 97.53  zero\_crossings\_per\_sec 55.87  percentage\_flatline 0.00  large\_jumps 0.00  range\_uV 213.36  symmetry\_corr\_LR 0.88  dtype: float64 |
| ECFP1 | ECFP2 |
| alpha\_power\_uV2 95.41  beta\_power\_uV2 283.02  delta\_power\_uV2 99.65  line\_noise\_power\_uV2 24.02  zero\_crossings\_per\_sec 53.59  percentage\_flatline 0.00  large\_jumps 0.00  range\_uV 157.22  symmetry\_corr\_LR 0.94 | alpha\_power\_uV2 118.92  beta\_power\_uV2 352.22  delta\_power\_uV2 185.26  line\_noise\_power\_uV2 41.00  zero\_crossings\_per\_sec 51.45  percentage\_flatline 0.00  large\_jumps 0.00  range\_uV 175.21  symmetry\_corr\_LR 0.94 |

**Symmetry Correlation**

* High correlation values (~0.88–0.94) between FP1 and FP2 electrodes demonstrate consistent and symmetric brain activity measurements, confirming recording reliability on both sides.

**Data Variability**

* When computing the noise ratios, the interquartile ranges (IQRs) across the three recordings were low to moderate, indicating good reproducibility and consistency of the measurements.

| **Condition** | **Cable Type** | **Delta** | **Theta** | **Alpha** | **Beta** |
| --- | --- | --- | --- | --- | --- |
| **Eyes Open** | FP1 (Thick) | 1.04 ± 0.17 | 0.96 ± 0.09 | 0.70 ± 0.03 | 2.19 ± 0.34 |
|  | FP2 (Thin) | 2.12 ± 0.50 | 1.37 ± 0.07 | 0.89 ± 0.02 | 2.71 ± 0.37 |
| **Eyes Closed** | FP1 (Thick) | 1.05 ± 0.29 | 1.29 ± 0.02 | 0.94 ± 0.14 | 2.67 ± 0.20 |
|  | FP2 (Thin) | 1.83 ± 0.70 | 1.74 ± 0.18 | 1.10 ± 0.10 | 3.14 ± 0.25 |

*Mean ± IQR of Band Noise Ratios (3 recordings)*

**Statistical Observations**

* Eyes Closed: Alpha and beta band powers were significantly higher in FP2 (thin cable), showing a trend despite limited sample size (3 recordings).
* Eyes Open: A trend toward higher values in FP2 was also observed, though statistical significance could not be established with the current sample.

### Conclusions

* The thinner 28 AWG cable (FP2) generally provides better EEG signal quality compared to the thicker 26 AWG cable (FP1).
* This is supported by higher signal-to-noise ratios, stronger EEG power metrics, and consistent signal quality indicators.
* Both cables show reliable and symmetric signal recordings, but the thin cable may offer improved noise resistance or attenuation.

### Future Work

* Additional Analyses:
  + Coherence analysis with multiple electrodes to assess spatial signal properties (requires more electrodes).
  + Phase lag analysis to detect potential delays introduced by cable properties.
  + Evaluation of signal-to-artifact ratios for deeper quality assessment.
* Good Practices:
  + Increase number of recordings and subjects to strengthen statistical power.
  + Test mechanical durability and flexibility of cables under stress conditions relevant for design improvements.
  + Evaluate environmental noise susceptibility in different settings (near power lines, indoors/outdoors).
  + Conduct longer duration recordings to assess stability over time.