# Simple procedures to help mitigate the influence of Hair Type and Texture on ERP Data Quality

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## Background

Despite the wide-spread perspective that certain hair types and hair styles may compromise EEG/ERP data quality, no empirical evidence regarding the impact of participant hair has been examined. As researchers work to expand the inclusiveness of participants in EEG/ERP research, guidance on specific practices and techniques that ensure data quality is needed.

## Aims

We aimed to evaluate these assumptions and determine if and how:

1. Differences in hair type impact various features of raw recorded and pre-processed EEG data, as well as analysis-ready ERP data; and,
2. Those impacts are alleviated by accounting for individual differences in hair volume.

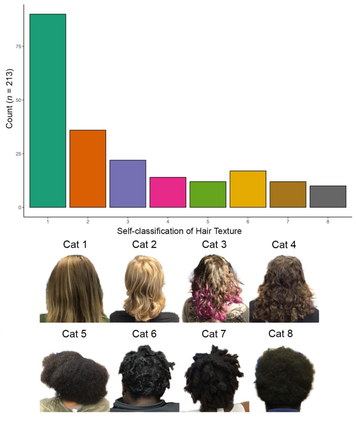
## Methods

***Participants***

- 213 young adults ($M_{age}$ = 18.34, $SD_{age}$ = 0.42; 48.36% female) from economically disadvantaged rural regions of PA and NC.
- 69% White or Caucasian, 24% Black or African American, 7% Multi-racial.

***Difference in Hair Type***

- Participants self-reported their hair-type using the 8 categories developed by *de la Mettrie, et al., 2006* and *Loussouarn et al., 2007.*
- These categories were developed based on a physical assessment of:
  - Curve Diameter i.e., the arc of hair.
  - Curl Meter i.e., if the hair fits into a circle of a specific size.
  - The number of wave crests within a 4 cm measure of hair.




- Research assistants used graduated syringes to quantify the amount of electrode gel in milliliters used in the EEG cap set-up ***(i.e., gel volume)***.
- Participants were divided into two groups (Group 1 = Categories 1– 4, n = 161; Group 2 = Categories 5 – 8, n = 52) prior to analysis.

## EEG Data Collection & Metrics

- EEG data were recorded using a 34- Channel Biosemi ActiveTwo System.
- Collected during a resting baseline and the Monetary Incentive Delay Task.

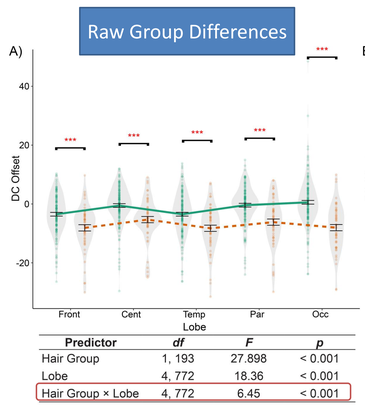
***Data Quality Metrics***

1. Raw recorded data were evaluated using the DC Offset calculated as the mean voltage across the full recording.
2. After passing through a fully automated pre-processing pipeline (bad channels removed, bandpass filter at 0.1 – 30 Hz, ICA to remove eye and muscle activity) pre-processed data were evaluated using a Signal-to-Noise Ratio calculated as: $SNR = 10 \cdot log_{10} \frac{\sum_{(i=1)}^{N} x_i^2}{\sum_{(i=1)}^{N} (s_i - x_i)^2}$
3. P1 and P3b ERP amplitude was used to represent analysis ready data.

## Results

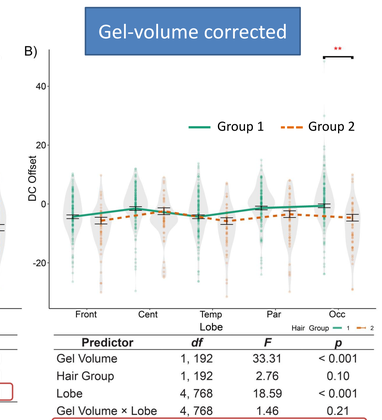
**Model 1: Baseline DC Offset values**

Raw Group Differences



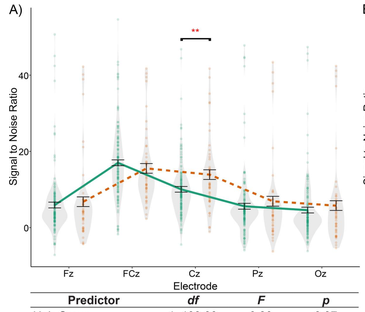

| Predictor | df | F | p |
|---|---|---|---|
| Hair Group | 1, 193 | 27.898 | < 0.001 |
| Lobe | 4, 772 | 18.36 | < 0.001 |
| Hair Group × Lobe | 4, 772 | 6.45 | < 0.001 |

Gel-volume corrected

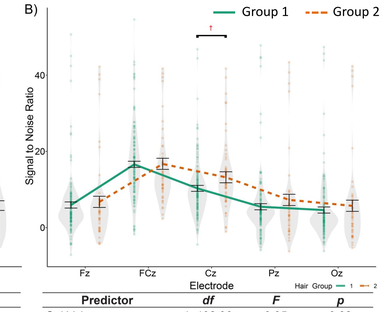



| Predictor | df | F | p |
|---|---|---|---|
| Gel Volume | 1, 192 | 33.31 | < 0.001 |
| Hair Group | 1, 192 | 2.76 | 0.10 |
| Lobe | 4, 768 | 18.59 | < 0.001 |
| Gel Volume × Lobe | 4, 768 | 1.46 | 0.21 |
| Hair Group × Lobe | 4, 768 | 2.46 | 0.04 |

**Model 2: Baseline Signal-to-Noise ratio**



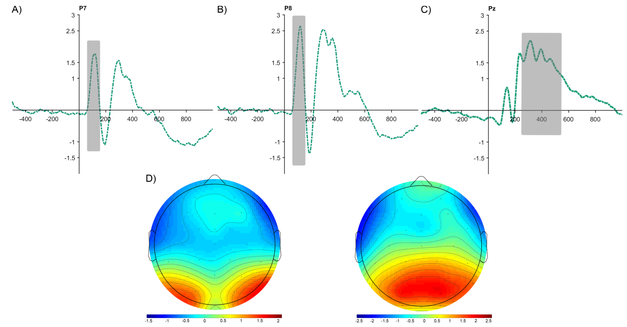

| Predictor | df | F | p |
|---|---|---|---|
| Hair Group | 1, 193.09 | 0.80 | 0.37 |
| Electrode | 4, 730.02 | 130.99 | < 0.001 |
| Hair Group × Electrode | 4, 730.02 | 5.34 | < 0.001 |



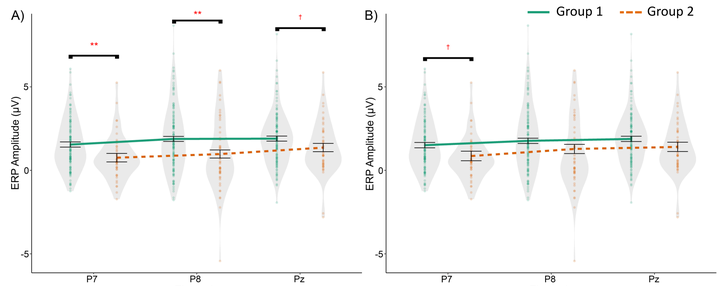

| Predictor | df | F | p |
|---|---|---|---|
| Gel Volume | 1, 192.96 | 0.05 | 0.82 |
| Hair Group | 1, 192.27 | 0.78 | 0.38 |
| Electrode | 4, 725.88 | 125.02 | < 0.001 |
| Gel Volume × Electrode | 4, 726.06 | 2.97 | 0.02 |
| Hair Group × Electrode | 4, 727.20 | 1.17 | 0.32 |

- Hair groups differ in data quality metrics, but ***these differences are mitigated or eliminated when accounting for gel volume***.
- Comparable results were observed using data from the MID task.

**Figure 2: Grand average P1 and P3b waves and topographies for all participants**




**Model 3: Comparison of ERP amplitude values between self-categorized hair groups across the P7, P8, and Pz electrodes**




| Predictor | df | F | p |
|---|---|---|---|
| Hair Group | 1, 176.42 | 15.60 | < 0.001 |
| Electrode | 2, 345.94 | 3.02 | 0.05 |
| Hair Group × Electrode | 2, 345.94 | 0.49 | 0.62 |

| Predictor | df | F | p |
|---|---|---|---|
| Gel Volume | 1, 172.61 | 3.27 | 0.07 |
| Hair Group | 1, 174.71 | 6.07 | 0.01 |
| Electrode | 2, 344.20 | 2.76 | 0.06 |
| Gel Volume × Electrode | 2, 339.44 | 1.33 | 0.27 |
| Hair Group × Electrode | 2, 341.06 | 0.09 | 0.91 |

- Group differences in ERP amplitude also exist, such that on average participants with more textured hair had lower ERP amplitudes.
- ***These differences are reduced by accounting for gel volume.***

## Conclusions

***Measuring gel volume*** and including it ***as a covariate*** may help to account for individual differences in hair volume and ***significantly reduces group differences.***

- Such differences are highly problematic as they could be misattributed to cognitive differences among groups.
- It is worth noting that **these results apply to our system and ERP analysis**. Additional research is needed to evaluate:
  - Other EEG data-collection systems.
  - EEG derived indices of analysis e.g., spectral features.
  - Alternative measures of hair volume.

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