The Need to Examine Potential Measurement Bias in EEG and ERP Research.

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Diversification of EEG/ERP Research

Diversifying EEG/ERP research has been a recent topic of conversation and the target of several published works.

- These have often (but not always) focused on biases in recruitment and access, specifically regarding under-represented minorities whose hair type or style is perceived to be incompatible with EEG.

As the field works to address these issues, we must also consider/determine if there are potential biases within our methods and measurements.

- Biases systematically associated with race could be misinterpreted as psychological differences.
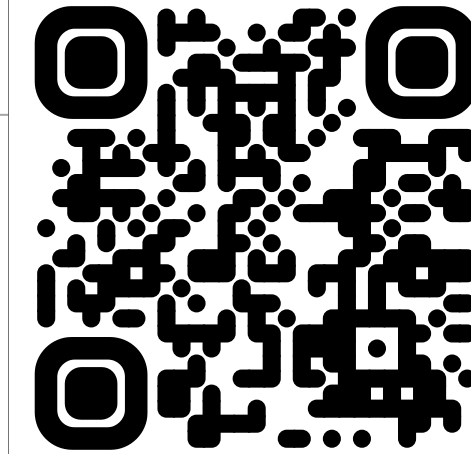
Bradford et al., 2022; Choy et al., 2022; Etienne et al., 2020; Lees et al., 2023; Parker & Ricard 2022; Webb et al., 2022

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ORIGINAL ARTICLE

The effect of hair type and texture on electroencephalography and event-related potential data quality

Ty Lees[1] | Nilam Ram[2,3] | Margaret M. Swingler[4] | Lisa M. Gatzke-Kopp[1,5]

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Abstract

Research utilizing event-related potential (ERP) methods is generally biased with regard to sample representativeness. Among the myriad of factors that contribute
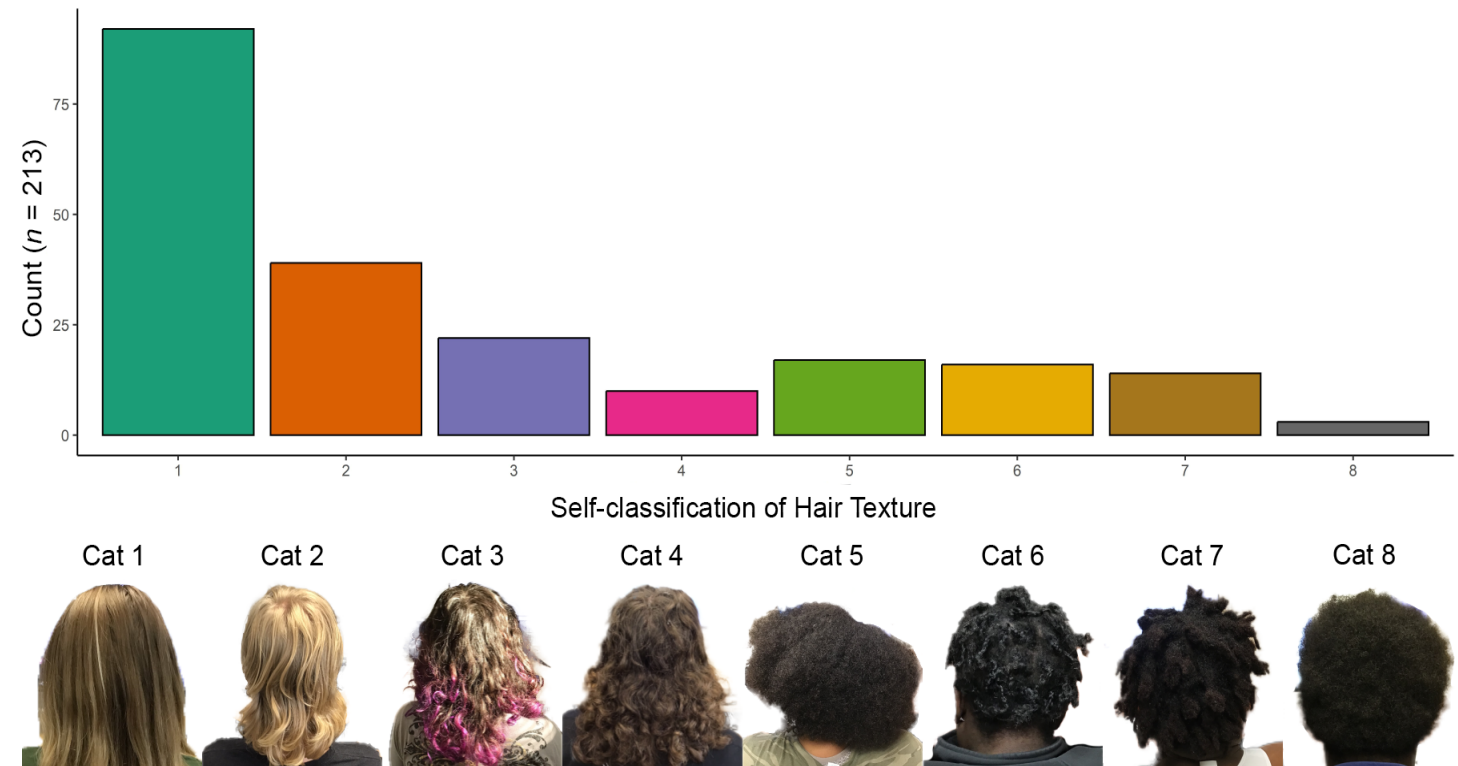
Participants and data collection

213 Participants

- 17 – 19 years; 69% White, 24% African American or Black, 7% Bi- or Multi-racial

Hair Categorisation

- Split into two groups
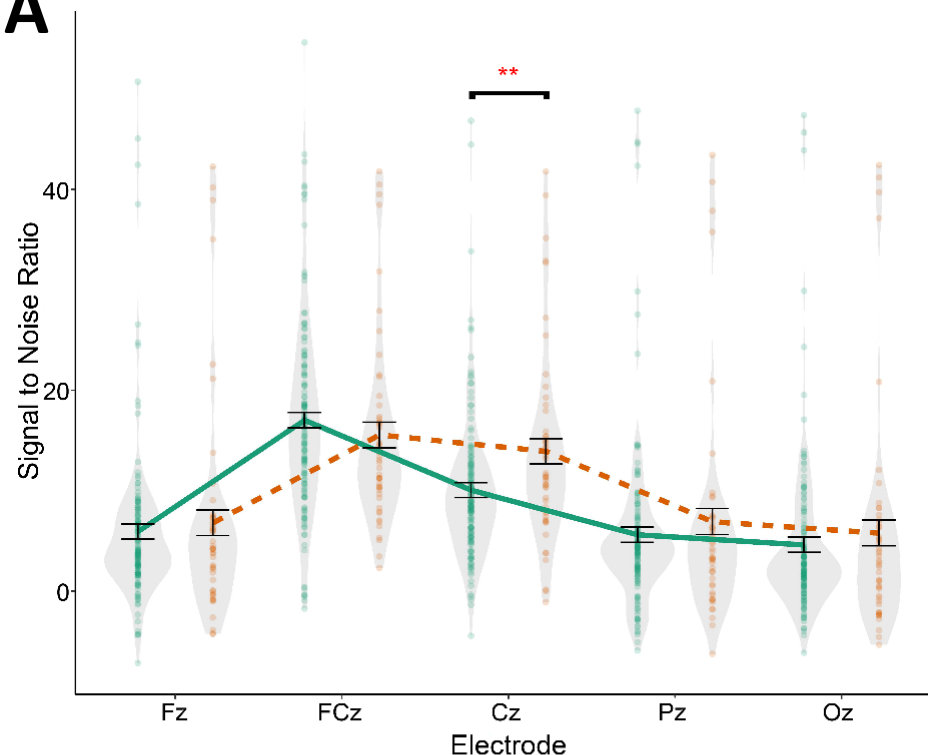- Group 1: Cat 1 – 3
- Group 2: Cat 4 – 8

Electrode Gel-Volume

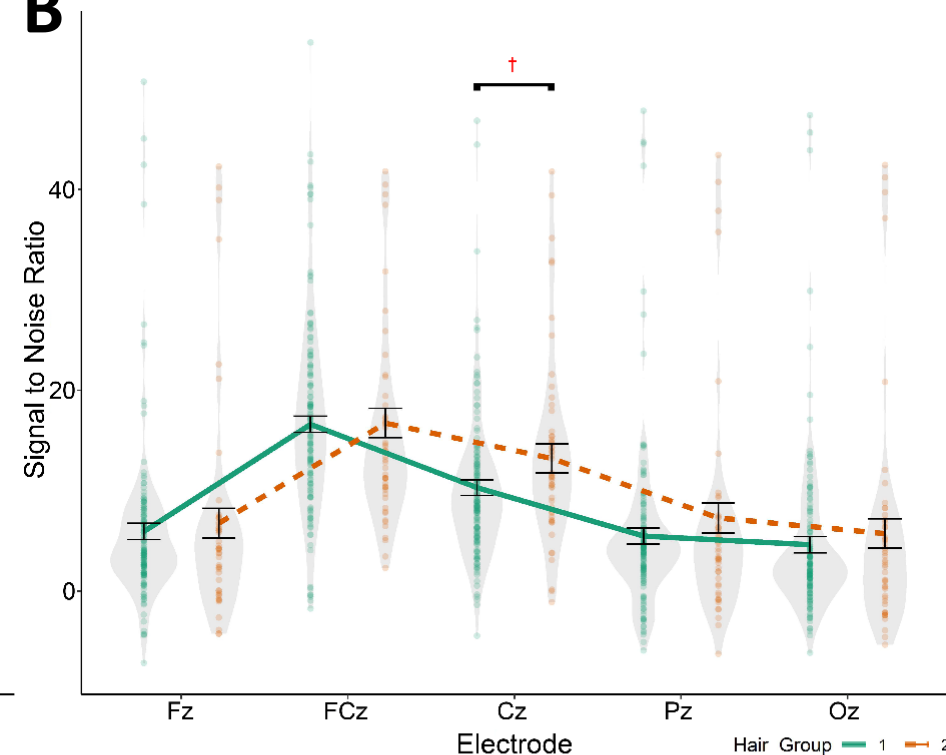- Graduated syringes used in the cap application and set-up

Signal to Noise Ratio

A

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

B

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

Lees, Ram, Swingler, & Gatkze-Kopp, 2023

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ERP Amplitude

A

B

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

C

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

Lees, Ram, Swingler, & Gatkze-Kopp, 2023

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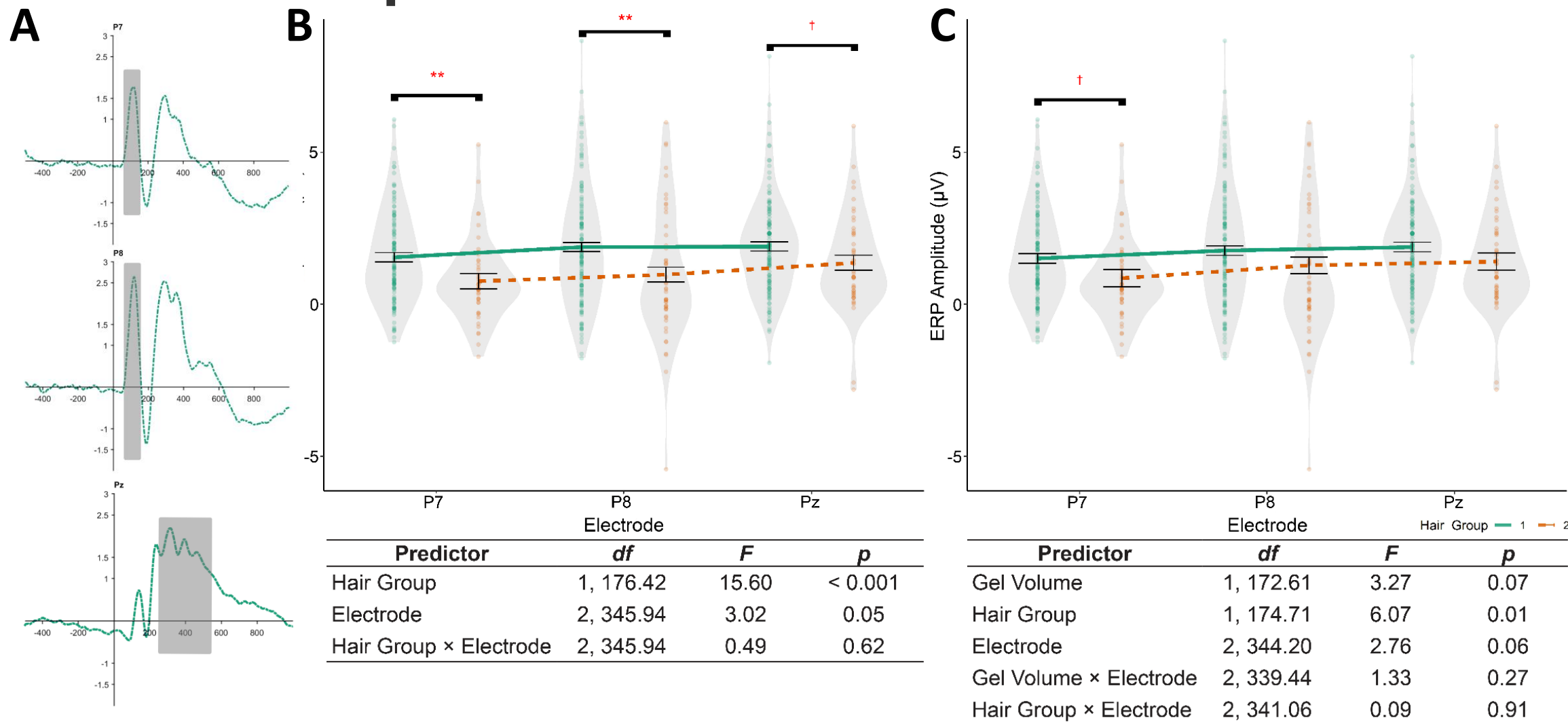
Hair volume contributes to distance between the electrode and scalp and may influence signal strength.

This assumption may be violated by the potentially systematic differences in hair volume including:

- Racially correlated differences in follicle density and hair shape/type
- Differences in hair styles (may also differ with participant gender)

Measuring gel volume provides a more accurate, individualized, and sensitive measure of individual differences that can account for this potential confound.

FUTURE RESEARCH CONSIDERATIONS

Hardware Design & Choices
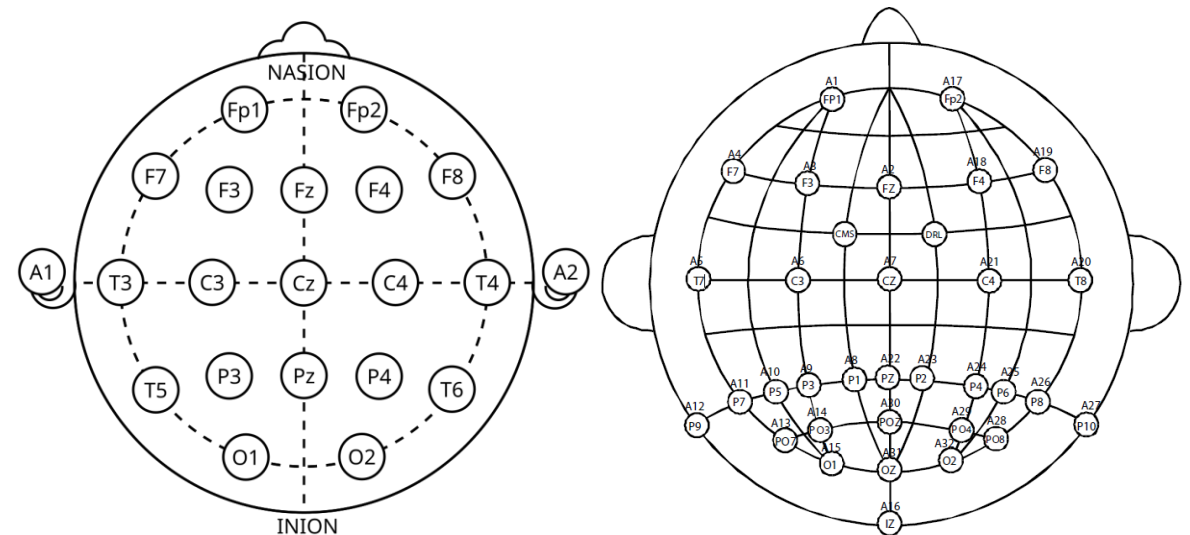
Electrode Design

- Disc vs. Cup vs. Pin vs. Multi-Pin

Electrode Impedance

- Acceptable values – 5/10/50 kΩ?
- Alternatives, i.e., DC offset?

Montage Size & Distribution

- How many electrodes are needed?

Data Processing & Parameterisation

What is Signal and what is Noise?

- Recording level vs. Parameter specific

$$SNR = 10 \cdot log_{10} \frac{\sum_{(i=1)}^{N} x_i^2}{\sum_{(i=1)}^{N}(s_i - x_i)^2}$$

What is an acceptable value?

- Absolute vs. Parameter specific
- Average vs. Pooled electrodes vs. Individual electrodes
- Between vs. Within-person

Measurement Confounds

- Regions of the head

As we push to diversify our participant groups, we should also evaluate our methods for biases.

With the goal being to ensure that psychophysiology parameters are interpreted correctly for all participants, and the eventuation of bias-free methods.

- Presence of method-based biases should not lead to the routine screening and exclusion of participants.
  - Known biases can be controlled for and/or designed away.

- 2023 Psychophysiology editorial provides key notes and recommendations on diversification efforts.

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