The Heritability of Frontal EEG Asymmetry: Reference & Sex Differences

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Abstract/Introduction

- Psychopathological phenotypes are often heterogeneous and comorbid with other types of pathology suggesting overlapping disease pathways or mechanisms with complex biological & psychosocial factors.
- The endophenotype approach can help parse disease heterogeneity into more homogeneous phenotypes allowing for examination of neurophysiological mechanisms underlying causal disease pathways (2)
- Frontal EEG asymmetry (FA) has been investigated as one of these potential endophenotypes (3,5,6)
- Frontal EEG asymmetry has been associated with depression (1,5,6) and anxiety (1, 10), but more generally with variations in behavioral and motivational styles that may confer risk when an at-risk individual faces stress (3, 4).
- If FA is to be established as an endophenotype, reliable heritability estimates need to be established.
- Previous research has estimated the heritability of FA, but results are mixed and may be the result of varied reference montages
- This research extends the previous work on the heritability of EEG asymmetry by comparing the common EEG recording montages AVG, CZ, LM & CSD.

Methods

Participants:

- From the Minnesota Center for Twin and Family Research (MCTFR), 799 pairs of twins were analyzed.
- Cohorts collapsed across age for initial analysis (66% MZ, 50% male [overall sample])

Data Collection, Reduction & Analysis:

- 5 minutes of resting EEG recorded, counter balancing eyes open and closed using 64-channel EEG cap with 256Hz sampling rate.
- All data analysis performed with custom Matlab scripts using function from EEGLab version 9.0.0.2b. (7)
- All Artifact-free epochs transformed to 3 different reference montages; including Average (AVG), Cz, Linked Mastoids (LM) and the reference-free montage Current Source Density (CSD) that attenuates contribution of distal sources.
- A Fast Fourier Transform (FFT) (Hamming-window) was used to extract alpha power and Alpha asymmetry scores computed using ln-transformed alpha power (ln[Right]-ln[Left]) between homologous sites.
- Heritability estimated for only frontal site pairs of F1/2, F3/4. F5/6 & F7/8.

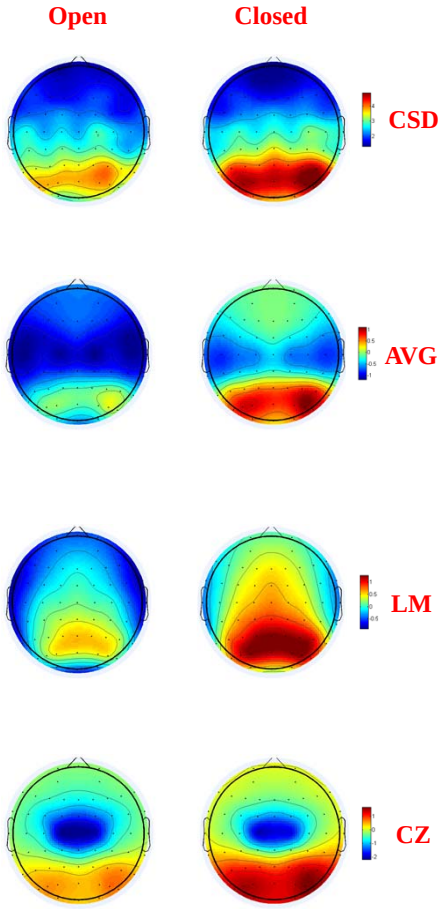
Modeling & Statistics:

- The Intra-class correlations were calculated in SPSS then used to estimate Falconer's heritability estimates. (9).
- Formula: $h_b^2 = 2(rmz - rdz)$
- On occasion, intra-class correlations are estimated to be less than zero. In such instances, the correlation is generally assumed to be zero, and this assumption was made in for the presented analyses.

Results

Topographic Distribution of Alpha Power for Eyes Open and Closed for Each Transformation

- For all transformations, greater occipital alpha is seen in eyes closed than open, as expected
- Only the CSD transformation, however, constrains occipital alpha to occipital sites
- AVG, CZ, and LM references montages allow occipital alpha to be reflected in frontal sites, especially under eyes closed conditions
- For these three reference montages, the heritability of frontal asymmetry may thus reflect heritability of not only frontal alpha, but alpha from distal sources as well



Heritability of EEG Asymmetry Modeled using Falconer's Broad Sense Heritability Estimate: $h_b^2 = 2(rmz - rdz)$

Tabled values represent ICCs for twin pairs by Zygosity and Broad-Sense heritability estimated by Falconer's Formula

	Mz=254; Dz=152			Mz=254; Dz=139		
	Males			Females		
Channel	MZ	DZ	h^2	MZ	DZ	h^2
F7/8	0.10	0.00	0.21	0.19	0.03	0.32
F5/6	0.03	0.21	0.00	0.05	0.01	0.07
F3/4	0.06	0.00	0.13	0.02	0.03	0.00
F1/2	0.06	0.00	0.11	0.00	0.00	0.00

	Mz=254; Dz=152			Mz=254; Dz=139		
	Males			Females		
Channel	MZ	DZ	h^2	MZ	DZ	h^2
F7/8	0.17	0.00	0.34	0.12	0.09	0.05
F5/6	0.14	0.00	0.28	0.02	0.00	0.04
F3/4	0.14	0.00	0.28	0.00	0.10	0.00
F1/2	0.03	0.00	0.05	0.00	0.05	0.00

	Mz=254; Dz=152			Mz=254; Dz=139		
	Males			Females		
Channel	MZ	DZ	h^2	MZ	DZ	h^2
F7/8	0.14	0.09	0.09	0.11	0.09	0.05
F5/6	0.12	0.05	0.15	0.01	0.00	0.02
F3/4	0.10	0.06	0.08	0.00	0.07	0.00
F1/2	0.11	0.02	0.17	0.00	0.00	0.00

	Mz=254; Dz=152			Mz=254; Dz=139		
	Males			Females		
Channel	MZ	DZ	h^2	MZ	DZ	h^2
F7/8	0.08	0.00	0.17	0.09	0.10	0.00
F5/6	0.08	0.00	0.15	0.02	0.00	0.04
F3/4	0.11	0.00	0.22	0.00	0.12	0.00
F1/2	0.00	0.00	0.00	0.00	0.10	0.00

Discussion

- Modest genetic contributions to frontal asymmetry are seen for all EEG transformations.
- Only the CSD transformation provides frontal asymmetry data that is not reflecting sizable contributions from distal sources. Thus heritability estimates of CSD-derived asymmetry should best reflect heritability of frontal asymmetry specifically.
- Estimates further indicate that, on average, frontal asymmetry displayed greater heritability at lateral channel pairs then their medial counterparts across models and gender.
- Models also demonstrate some gender effects, as Frontal EEG asymmetry and more medial sites showed greater heritability for men compared to women,
- This sample also consisted of two separate age cohorts, the combination of which may have masked some unique age-related contributions to frontal EEG asymmetry. Future work will examine heritability separately by age.
- Although these data use a Broad-sense estimation of heritability, the results warrant the use of more sophisticated modeling techniques such as Structural equation modeling (SEM) to further parse variance in appropriate genetic and environmental components.
- The use of Broad-Sense heritability calculations may mask some important specific genetic interactions (additive vs non-additive vs epistatic), as indicated by the variability of ICCs.
- Regardless of the above limitations, these estimates of heritability of frontal EEG asymmetry suggest its possible utility as a potential endophenotype to be pursued in further research.

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