



# A Comparison of Cordance and Traditional EEG Asymmetry in Depression



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## Abstract

Cordance is a relatively new electroencephalographic measure that shows close correspondence with underlying cerebral perfusion. Cordance involves reattribution of absolute power values from bipolar channels involving a particular electrode to that electrode, as well adjusting each site's reattributed power values for total power across bands and sites. Whereas ample findings using conventional EEG have demonstrated a relationship between frontal alpha power asymmetry and emotion or psychopathology, comparatively little work has linked frontal EEG asymmetry to underlying brain systems. The present study was thus designed to compare alpha (8-13 Hz) asymmetry between traditional EEG and Cordance, and to examine the psychometric properties of Cordance. In a sample of 28 women with major depression, treated over a period of 8 or 16 weeks, Cordance asymmetry exhibited relatively good internal consistency, but only moderate stability across the different assessments. Furthermore, change in Cordance asymmetry over time did not exhibit any relationship to depressive severity, to treatment response, or to the likelihood of relapse. Compared to findings with traditional EEG (referenced to Cz, linked mastoids, or average reference), Cordance asymmetry shows comparable internal consistency, lower stability, and a similar pattern of no relationship to clinical status. The correlations between Cordance asymmetry and conventional asymmetry under the different reference schemes were somewhat inconsistent, but were generally stronger for Cz-referenced data than for linked-mastoids or average-referenced data. The present findings suggest that traditional measures of resting EEG asymmetry show low-to-modest correspondence with Cordance and, by inference, with measures of underlying cerebral perfusion.

## Introduction

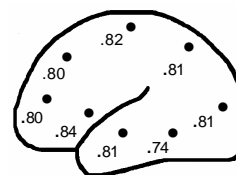
- ❑ Research has implicated a connection between depression and frontal EEG asymmetry
  - ❑ a pattern of less left than right frontal activity appears to characterize depressed individuals (Allen et al., 1993; Allen, Iacono, Depue & Arbisi, 1993; Henriques & Davidson, 1991)
  - ❑ other researchers did not find these results (Reid, Duke & Allen, 1998)
- ❑ Researchers have found an association between Cordance and other measures of brain function and lesions
  - ❑ Leuchter et al., (1994) found strong connections between
    - ❑ discordance (i.e. negative values of cordance) and MRI in Patients with White-Matter Lesions (n=4) in the  $\beta 1$ - and  $\gamma$ -band
    - ❑ discordance and PET in Patients with Metabolism disorders (n=2) in  $\beta 1$ -band
    - ❑ discordance and SPECT in Patients with Hypoperfusion (n=2) in  $\beta 1$ - and  $\gamma$ -band
  - ❑ Leuchter et al., (1999) found significant associations between QEEG and perfusion in normal subjects (n=6) in the alpha band (8-12 Hz)
- ❑ Few data are available linking frontal EEG asymmetry to underlying cortical function
  - ❑ Cordance asymmetry was therefore examined as a potential measure that may show closer correspondence to underlying cortical activity

## Methods

- ❑ **Participants**
  - ❑ 38 Women, age 18-45, diagnosed with a Major Depression based on the DSM-IV; No comorbid diagnoses
  - ❑ Hamilton score mean 25.1 ( $\pm 7.0$  s.d.)
- ❑ **Procedure**
  - ❑ EEG was assessed prior to the start of treatment (Baseline) and again at monthly intervals.
  - ❑ Recording Specifics
    - ❑ Twenty-five electrodes
    - ❑ Recorded resting EEG for 8 minutes (eyes open and closed)
    - ❑ EEG and ocular sites were referenced to A1 online
    - ❑ Data recorded with AC differential amplifiers (0.1 to 100 Hz)
    - ❑ Data digitized continuously at 512 Hz
- ❑ **Data reduction**
  - ❑ Each record visually screened for movements and artifact
  - ❑ Blink activity greater than  $\pm 50$  microvolts removed
- ❑ **Cordance Data processing**
  - ❑ Each electrode re-referenced to a series of bipolar channels, one for each of the four nearest neighbors
  - ❑ Each one minute block was divided into 119 two-second epochs
  - ❑ FFT performed on each bipolar-referenced epoch after weighting with a Hamming window
  - ❑ Absolute alpha (8-13 Hz) power was reattributed and Cordance values calculated using the macros of Cook et al. (1998)
- ❑ **Internal Consistency Estimates**
  - ❑ Cordance asymmetry for each one minute epoch was treated as an "item" on an eight-item scale, with Cronbach's Alpha as the estimate of internal consistency reliability
- ❑ **Intraclass Correlations Coefficients (ICC) to Assess Stability**
  - ❑ ICCs were derived using a one-way random effects model, which corresponds to model (1,1) of Shrout and Fleiss (1979). These estimates allow one to interpret the ICCs to reflect the extent to which one might expect asymmetry scores to remain stable across any given set of assessments while subjects experience changes in clinical status over time (see Allen, Urry, Hitt, & Coan, in press)

## Results

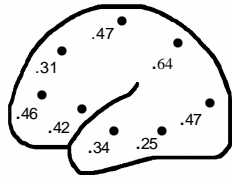
### Cordance Asymmetry Internal consistency (Cronbach's Alpha)



- ❑ **Cordance:** The averaged Internal consistency across all five assessments ranged from .74 to .84 depending on scalp site
  - ❑ Internal consistency at each individual assessment period ranged from .68 to .92, with a median of .80
- ❑ **Comparison:** Internal consistency using conventional methods (Cz, Averaged Mastoids, and Average Reference) were comparable
  - ❑ Across assessment periods and sites, Cronbach's Alpha ranged from .37 to .94 with a median of .85 (Allen, Urry, Hitt, Coan, in press)

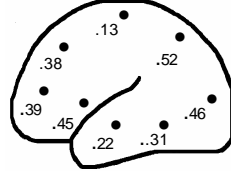
## Cordance Asymmetry Stability (Intraclass Correlation)

8 Weeks



N of 22 (T4-T3), 23 (T6-T5, F8-F7), 24 (T4-T3), or 25 (all other sites) for three assessments

16 Weeks



N of 12 (T4-T3, T6-T5), 13 (F8-F7, C4-C3), 14 (O1-O2, P4-P3), or 15 (all other sites) for five assessments

**Cordance:** Cordance asymmetry ICC's ranged from .25 to .64 over 8 weeks (Median = .44), and from .13 to .52 over 16 weeks (Median = .38)

**Comparison:** Comparable IIC stability values for conventional asymmetry scores (Cz, Averaged Mastoids, and Average Reference; Allen et al, in press) were higher:

□ ICCs ranged from .41 to .77 over 8 weeks, and from .33 to .85 over 16 weeks.

□ Median ICCs across three assessments: .62 for average-referenced, .73 for Cz-referenced, and .57 for averaged mastoid references

□ Median ICCs across five assessments: .61 for average-referenced, .54 for Cz-referenced, and .61 for averaged mastoid references

## Correlation with Conventional Asymmetry

### Average Reference

Region	Baseline	4 weeks	8 weeks	12 weeks	16 weeks
C4C3	0.19	0.22	0.21	0.11	-0.12
F4F3	-0.26	0.43*	-0.34	0.11	-0.32
F8F7	0.42*	0.09	0.27	0.11	0.29
FP2FP1	-0.06	0.41*	-0.17	0.56*	0.20
O2O1	0.36	0.76**	0.45*	0.64**	0.69**
P4P3	0.24	0.45*	0.28	0.57*	0.23
T4T3	0.09	0.17	0.32	0.18	0.25
T6T5	0.49**	0.58**	0.49**	0.43	0.81**

### Cz Reference

Region	Baseline	4 weeks	8 weeks	12 weeks	16 weeks
C4C3	0.7**	0.08	0.51**	0.47*	0.52*
F4F3	0.06	0.30	-0.02	0.38	0.03
F8F7	0.65**	0.16	0.65**	0.39	0.57*
FP2FP1	0.13	0.15	-0.12	0.38	0.33
O2O1	0.34	0.72**	0.42*	0.65**	0.67**
P4P3	0.40*	0.57**	0.33	0.62**	0.34
T4T3	0.45*	0.48*	0.65**	0.54*	0.57*
T6T5	0.51*	0.57**	0.45*	0.45	0.77**

### Averaged Mastoids Reference

Region	Baseline	4 weeks	8 weeks	12 weeks	16 weeks
C4C3	0.11	0.25	0.07	0.09	-0.04
F4F3	-0.10	0.28	-0.16	-0.03	-0.17
F8F7	0.60	-0.07	-0.16	-0.11	-0.11
FP2FP1	-0.03	0.4*	-0.26	0.45	0.02
O2O1	0.35	0.69**	0.52**	0.55*	0.67**
P4P3	0.11	0.09	0.08	0.43	0.13
T4T3	0.00	0.15	-0.06	-0.11	-0.17
T6T5	0.33	0.35	0.21	-0.09	0.47

p < .05 \* p < .01 \*\*

Correlations reflect the pearson correlation between Cordance asymmetry (R-L) and conventional asymmetry (ln[R]-ln[L])

## Relationship to clinical status

- Cordance asymmetry is not related to severity at baseline (N=28)
  - midfrontal (r=-.26); frontal-temporal (r=.19); lateral-frontal lead (r=.17)
- Cordance asymmetry is not related to treatment response in depressive severity across 8 weeks (N=28)
  - midfrontal (r=.05); frontal-temporal (r=.02); lateral-frontal lead (r=.19)
- Cordance asymmetry is not related to relapse status (N=23)
  - midfrontal (r=.02); frontal-temporal (r=.03); lateral-frontal (r=.26)

## Discussion

- Cordance asymmetry can be reliably recorded, and demonstrates internal consistency estimates that are comparable to those observed with alpha asymmetry scores derived using standard reference schemes (Cz, Average Reference, Averaged Mastoids Reference)
- By contrast, Cordance asymmetry is substantially less stable across repeated assessments than conventionally referenced data.
  - Greater instability suggests the possibility that Cordance asymmetry is more closely linked to occasion-specific variance in mood or symptoms
  - Yet Cordance asymmetry is not related to clinical status, including baseline severity, treatment response, or likelihood of relapse
- Cordance asymmetry shows only modest correlations with conventional asymmetry, although it is most consistently correlated with Cz-referenced data.
  - This is somewhat surprising, as one would expect the Cordance re-referencing to accentuate local activity by virtue of the referencing to nearest neighbors, while one would expect the Cz reference to accentuate diffuse activity picked up at the vertex.
  - The relatively poor convergent validity of Cordance asymmetry with conventional asymmetry suggest that these measures may tap different constructs
    - Cordance asymmetry therefore may not be assumed to relate closely to the larger literature on emotion and psychopathology

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