A Comparison of Cordance and Traditional EEG Asymmetry in Voluntary Facial Expressions

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Abstract

Cordance is a relatively new electroencephalographic measure that shows close correspondence with underlying cerebral perfusion (Leuchter et al., 1994). Cordance involves reattribution absolute power values from bipolar channels involving a particular electrode to that electrode.

The present study was designed to compare alpha (8-13 Hz) asymmetry between Cordance and traditional EEG. Brain activity was monitored while 36 participants produced voluntary facial expressions according to the approach/withdrawal motivational model of emotions. This model suggests that "approach" emotions (joy and anger) evoke relatively greater left frontal brain activity whereas "withdrawal" emotions (disgust, fear and sadness) evoke relatively greater right frontal brain activity.

Asymmetry using Cordance can be reliable measured during states. Replicating findings with traditional EEG, withdrawal expressions produced a bilateral increase in frontal alpha. Laterality effects were weaker with Cordance than with traditional EEG, although a trend into the same direction was observed, such that withdrawal faces produced relatively greater left alpha using Cordance.

The correlations between traditional asymmetry and Cordance asymmetry are rather inconsistent. The Cz- referenced data and Cordance data show strong correlations in all conditions whereas linked-mastoids data and average- referenced data shows strong correlations only in the withdrawal condition. The findings show only low correspondence between traditional measure of EEG asymmetry and Cordance.
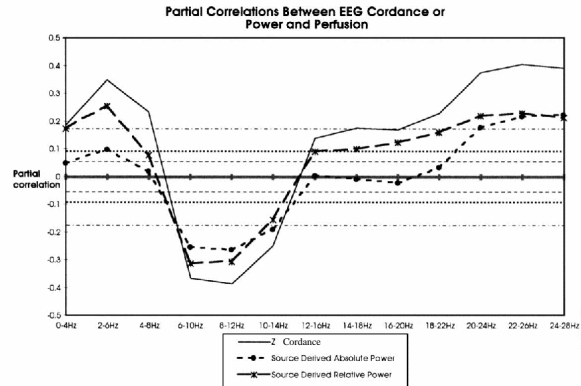
Introduction

- ❑ Ongoing Research has implicated that voluntary facial movements may be capable of eliciting specific response in the CNS.
  - ❑ Ekman and Davidson (1993) found that smiles that included activation of the *orbicularis pars lateralis,* referred to the Duchenne's Marker, resulted in relatively greater left frontal activity compared to smiles that did not include this movement.
  - ❑ Coan, Allen, & Harmon-Jones (2001) found that faces depicting emotions consistent with withdrawal corresponded with relatively greater right frontal activity, in the context of a bilateral decrease in frontal activity
- ❑ 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 ß1- and ?-band
    - ❑ discordance and PET in Patients with Metabolism disorders (n=2) in ß1-band
    - ❑ discordance and SPECT in Patients with Hypoperfusion (n=2) in ß1- and ?-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

Cordance and Perfusion

Leuchter et al. (1999) report that Cordance shows a closer relationship to underlying cortical perfusion than does absolute EEG power or relative EEG power. Note that in the following figure from Leuchter et al. (1999) that alpha power shows the predicted inverse relationship to underlying cortical perfusion

A.F. Leuchter et al. / Psychiatry Research: Neuroimaging Section 90 (1999) 125–140

Partial Correlations Between EEG Cordance or Power and Perfusion

Plot showing the partial correlation coefficient between EEG power and cordance values [$Z_{(i,f)}$], and relative perfusion as a function of frequency band. Statistical significance is indicated by horizontal lines representing the magnitude at which a correlation coefficient attains significance: dashed line (- - - -) for $P = 0.05$; dotted line (· · ·) for $P = 0.01$; dotted–dashed line (– · –) for $P = 0.001$. (Plot from Leuchter et al., 1999)

Methods

- ❑ **Subjects**
  - ❑ 36 Students (10 men, 26 women)
  - ❑ Between 17 and 24 years of age (mean age = 19.1)
  - ❑ All participants were strongly right handed
- ❑ **Procedure**
  - ❑ Participants directed to move facial muscles without mention of the intended configuration (anger, joy, sadness, fear, disgust, and three single action units)
  - ❑ Recording Specifics
    - ❑ Twenty-five electrodes
    - ❑ eight different facial movements were recorded for each participant
    - ❑ EEG and ocular sites were referenced online to Cz, and reverenced off-line using different reference schemes
    - ❑ Data recorded with AC differential amplifiers (0.1 to 300 Hz)
    - ❑ Data digitized continuously at 2048 Hz
- ❑ **Data reduction**
  - ❑ Each data file was filtered with a finite impulse resopnse digital 60 Hz notch filter
  - ❑ Each record visually screened for movements and artifact
  - ❑ Blink activity greater than ± 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 were divided into 117 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 20 second epoch was treated as an "item" on an six-item scale, with Cronbach's Alpha as the estimate of internal consistency reliability

Results

Cordance Asymmetry Internal consistency (Cronbach's Alpha)

	C3-C4	F3-F4	F7-F8	FP1-FP2	T3-T4
Anger	0.89	0.91	0.87	0.83	0.87
Joy	0.84	0.67	0.89	0.65	0.94
Fear	0.87	0.86	0.92	0.81	0.94
Sadness	0.80	0.82	0.86	0.47	0.79
Disgust	0.79	0.82	0.89	0.87	0.92
AU 12	0.87	0.80	0.86	0.64	0.91
AU 15	0.79	0.59	0.65	0.59	0.84
AU 4	0.89	0.86	0.87	0.70	0.93

❑ Cordance: The Internal consistency across all individual emotions ranged from .47 to .94 depending on scalp site, with a median of .86 .

❑ Comparison: Internal consistency using conventional methods were comparable
  ❑ Cronbach's Alpha ranged from .39 to .97 depending on the individual emotion, Region and reference scheme with a median reliability coefficient of .83 (Coan et al., 2001)
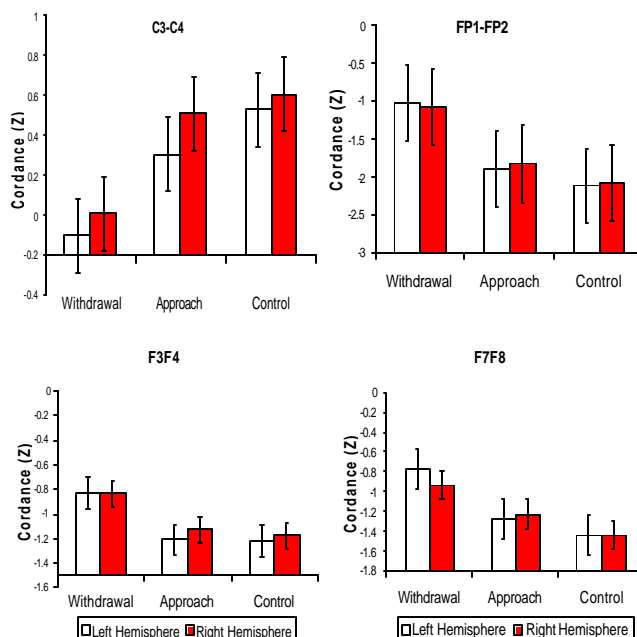
Correlation with Conventional Asymmetry

Average Reference			
	approach	withdrawal	control
f34	0.24	0.57**	-0.14
f78	0.26	0.61**	0.23
Cz Reference			
	approach	withdrawal	control
f34	0.51**	0.64**	0.39*
f78	0.48**	0.67**	0.51**
Linked Mastoids Reference			
	approach	withdrawal	control
f34	0.20	0.62**	-0.13
f78	-0.03	0.47**	-.37*

p <.05 *	p <.01 **

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

Response to Directed Facial Action

❑ Cordance: Greater bilateral frontal alpha power was observed during withdrawal than during the other conditions. The effect was not lateralized, however, as no significant Condition x Region x Hemisphere interaction was found

❑ Comparison: Standard measures of frontal alpha also showed increased bilateral alpha power during withdrawal compared to other facial poses. By contrast, an interaction of condition, region, and hemisphere was also found, and was the result of a larger increase in left than right frontal alpha power (Coan et al., 2001).

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).

❑ Although Cordance asymmetry showed bilateral frontal decreases in activity during withdrawal facial poses, it did not show lateralized changes like those with conventional asymmetry.

❑ The Cz- referenced data and Cordance data show strong correlations in all conditions.
  ❑ 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 it may tap a different construct, and may therefore not be assumed to relate closely to the larger literature on emotion and psychopathology.

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