A Better Estimate of the Internal Consistency Reliability Of Frontal EEG Asymmetry

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Abstract & Overview

Frontal alpha asymmetry is typically computed using average alpha power from many individual spectra, each the result of a Fourier transform derived from overlapping epochs. Previous reports estimated the internal consistency of asymmetry by dividing resting EEG sessions into segments of equal duration (e.g. 1 min) that are considerably longer than the individual epochs, calculating asymmetry scores using average alpha-band power within each segment. Such segments are treated as "items" on a "scale" intended to measure asymmetry, and reliability estimates are obtained with Cronbach's alpha. Since Cronbach's alpha increases with the number of items in a scale, estimates of reliability are influenced by the number of segments used. Reliability estimates in the present study were thus obtained by treating asymmetry scores from individual epochs as separate items, thus reflecting the true number of "items" that comprise the total score, avoiding the dependency on an arbitrary number of "items" that are summary scores across many individual epochs. Because the number of available epochs varied across subjects, a randomization procedure was used to estimate Spearman-Brown corrected split-half reliability coefficients, estimating reliabilities across a range of epochs (20 to 400) sampled from resting EEG data (100 subjects, 8 sessions). Asymmetry scores at all scalp sites and reference schemes (average, online, and linked-mastoids) approached 0.90 with as few as 100 epochs, suggesting the internal consistency of frontal asymmetry is greater than that previously reported.

Introduction

Frontal EEG Asymmetry: A growing literature

- Frontal EEG asymmetry, inferred from asymmetrical alpha power over homologous sites, is related to individual differences (e.g. Depression) as well as state-elicited changes in emotion (e.g. emotion to films, separation)
- Relatively less left frontal activity, surmised by relatively greater left frontal alpha differentiates depressed and previously depressed individuals from never depressed individuals
- Is relatively stable in clinical and nonclinical populations, with approx 60% of variance representing stable trait (e.g. Hagemann, 2002)

Assessing Internal Consistency of Frontal EEG Asymmetry

- Internal consistency of EEG alpha asymmetry is typically assessed by treating each one-minute recording period as an item on an eight-item scale, yielding relatively high Cronbach's Alpha estimates of internal consistency reliability (cf. Tomarken, Davidson, Wheeler, & Kinney, 1992).
- Such results have led many to utilize eight minutes as a recording standard, but perhaps unnecessarily
  - Coefficient Alpha is highly sensitive to the number of items utilized in estimating reliability (Lord & Novick, 1968)
  - Data summarized by minute will result in estimates for fewer than 8 minutes producing necessarily lower estimates of reliability given that fewer items will be used in the estimate
  - In fact, when 8 "chunks" of data are utilized, even 2 minutes of EEG data (eight 15-second chunks) can produce acceptable estimates of internal consistency reliablity (Allen, Urry, Hitt, and Coan, 2004)
- An appropriate procedure for estimating internal consistency reliability would not use arbitrary segments of data (e.g. one minute), but instead would utilize the actual "item-level" input to the asymmetry score; i.e., the single epochs.

Method

Subjects

- 104 paid undergraduate students (77 female)
- 19 met criteria for current Major Depressive Disorder (MDD), 41 met criteria for past MDD
- Beck Depression Inventory scores ranged from 0 to 43 (mean=10.7, median = 10)

EEG Procedure

- EEG data were recorded on 4-6 separate occasions, with two 8-minute resting periods on each occasion, comprised of eyes open and closed recordings in one of two orders (COOCOCCO, OCCOCOOC).
  - The mean alpha power for Set A and Set B was computed, and the asymmetry scores (ln(Right)-ln(Left) for homologous leads were computed.
- Scalp EEG recorded from 64 channels (including mastoids), with an online reference located between Cz and CPz. Vertical and horizontal EOG were recorded using bipolar leads. All data were low-pass filtered at 200Hz, and digitized at 1000Hz.
- Data also re-referenced to Averaged ("Linked") Mastoids (LM), and Average reference (AR; average of all EEG sites)
- Data segmented into 2.048 sec epochs overlapping by 75%
- Power extracted by FFT for each epoch after application of hamming window
- Asymmetry score for each epoch computed as ln(Right)-ln(Left) Alpha (8-13 Hz) Power.

Reliability Computations: Rationale and Implementation

- Problems with using coefficient Alpha for individual epochs
  - If all participants had all epochs, coefficient alpha could easily be computed treating each epoch as an "item" on a scale, and this could be computed for various numbers of epochs.
  - But because different epochs are lost for different subjects due to artifacts such as EMG and blinks, this approach will not work.
  - Coefficient alpha is, conceptually, the mean of all possible split-half reliabilities, already corrected for double length. Asymmetry scores based on split halves of available epochs for each subject can be constructed. Although the present approach will not compute the mean of "all possible" split half reliabilities, a large number of possible split halves (i.e., 1000) will be calculated and corrected for double length with the Spearman Brown Prophecy formula.
- Implementation
  - The procedure detailed below was implemented for different numbers of epochs ranging from 20 to 400.
  - To assess the internal consistency reliability for a given number of epochs *n*, on any given iteration for each subject, a sample of *n* epochs was randomly selected from among artifact free epochs, and half the epochs were randomly assigned to Set A or Set B.
  - Computed the correlation for asymmetry scores in Set A and Set B across participants, and corrected for double length with Spearman Brown. That correlation value was saved for each homologous pair.
  - After 1000 iterations had produced 1000 correlations for each homologous pair, these correlations were Fisher Z transformed and the average Fisher Z was obtained, after which this average Fisher Z was transformed back to correlation units.
  - This yielded the mean of "almost" all possible split half reliabilities.

Results

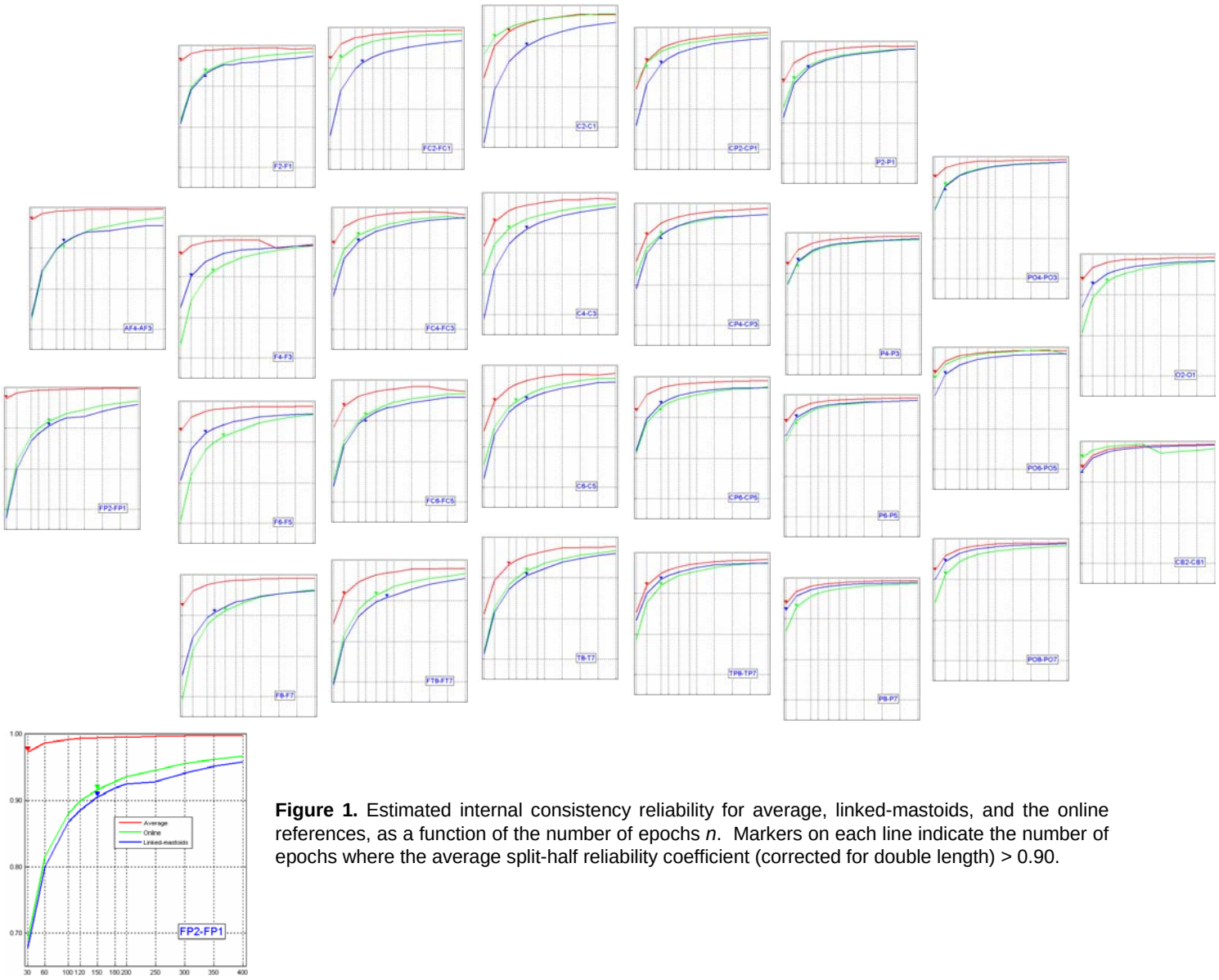

Figure 1. Estimated internal consistency reliability for average, linked-mastoids, and the online references, as a function of the number of epochs *n*. Markers on each line indicate the number of epochs where the average split-half reliability coefficient (corrected for double length) > 0.90.

Discussion

- Previous methods of computing internal consistency reliability were limited, primarily due to the dependence of coefficient alpha on the number of items used to estimate reliability.
- The present approach overcomes this limitation, and suggests that highly reliable estimates of Frontal EEG asymmetry can be obtained with 100 or more usable epochs.
- Although 100 overlapping epochs can be obtained in a one-minute recording period, longer recording periods may be desirable due to fact that up to half of the recorded epochs for any given file may be rejected prior to analysis due to artifacts

References

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