THE EFFECTS OF SEQUENTIAL VERSUS REFERENTIAL MONTAGE NEUROFEEDBACK AMPLITUDE TRAINING ON QEEG MEASURES OF PHASE AND COHERENCE

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An important clinical research question to be answered in the field of neurofeedback (NF) is whether amplitude training affects connectivity between cortical sites. This study hypothesizes that, following NF amplitude training, there will be a difference in QEEG coherence and phase measures between NF training done using referential montages and using sequential montages. The study examined case files of 16 adult clients from the University of North Texas Neurotherapy Lab who had received NF training that consisted of either referential or sequential placement amplitude training (no coherence training) and who received both pre- and post- treatment QEEGs. Sixty-eight percent of the cases consisted of referential placements, while 34% of the cases consisted of sequential placements. All frontal site phase and coherence abnormal *z*-scores at pre-treatment were converted to deviation scores and compared by general linear model analysis of variance to post-treatment deviation scores. Effect size *r*-values and eta square values indicate that differences between referential and sequential electrode placements after NF amplitude training are moderately high. This study shows that referential placements tend to increase phase scores and decrease coherence scores, while sequential placements tend to decrease phase scores and increase coherence scores.

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CHAPTER 1

INTRODUCTION

Background

The study of functional relationships between two brain regions and using two electrodes to record activity in different cerebral regions has been one of the controversial issues since the development of the electroencephalogram. In 1951, Brazier and Casby (1951, 1952) used the cross-correlation function to study the similarity of the frequencies and relationships of specific cellular regions between two quantitative-electroencephalograph (QEEG) signals. Many studies have identified the interrelationships between different cortical regions in relation to psychopharmacological drugs, sensory stimulation, motor behavior, clinical syndromes (Barlow, 1973), and different levels of alertness and consciousness (Barcaro, Denoth, Murri, Navona, and Stefanini, 1986). Both amplitude and coherence measures give insight to the type and severity of pathology (Armitage, 1995).

The study of the strength, or amplitude, of a brain wave has been useful in differentiating types of neurological and psychiatric syndromes. For example, positive symptoms of schizophrenia have been associated with changes in alpha amplitude (Ota, Toyoshima, Motomura, Maeshiro, Takazawa, Ohshima, Ishido, Aikawa, Tsukaha, Okada and Yamauchi, 1987), while increased delta and theta amplitudes are associated with major depressive disorder (Nystrom, Matousek, &

Hallstrom, 1986). Clinicians who use amplitude training in EEG biofeedback, or neurofeedback (NF), may use either referential or sequential electrode placement montages. Referential placements incorporate one active electrode, one reference electrode, and one ground, while sequential placements incorporate two active and one ground electrode. Researchers and NF clinicians continue to debate the utility and validity of referential and sequential placements (Goff, 1974; Lindsley, and Wicke, 1974; Reilly, 1987). Fehmi and Sundor (1989) indicate that the monopolar (referential) versus bipolar (sequential) controversy has been around since the development of the QEEG:

> Since the 1930s, the placement of the QEEG electrodes has been an ongoing controversy, exacerbated particularly during the past few decades. The controversy is centered over whether monopolar (also termed common reference or unipolar) electrode placement techniques are preferable to bipolar placement techniques.
> (p.23)

Fehmi and Sundor (1989) suggest that the debate favors referential placement recording over sequential placement recording. They report that the QEEG phase recording in sequential placement may not be a valid method in recording fluctuations of voltage when compared with referential placement. QEEG phase and coherence measures are inter-related and are indicative of the strength of connectivity in cerebral regions (Thatcher, 2005; Thatcher, Biver, McAlaster, Camacho, & Salazar, 1998; Thornton, 2002; Weiss & Mueller, 2003). Therefore, the essential clinical research question is whether sequential and referential electrode placement montage amplitude training differentially affect QEEG phase and coherence measures.

Definition of Phase and Coherence

Definition of Phase

In order to gain a full understanding of whether neurofeedback (NF) amplitude training affects phase and coherence measures, the definition and calculation of phase and coherence must be understood. Weiss and Mueller (2003) described the importance of phase in understanding the computation of coherence. Thornton (2002) defined phase as “the time lag between waves from two locations in a particular band as defined by how soon after the beginning of an epoch a particular waveform at location #1 is matched in location #2 (amplitude)…” (p.45). Thornton then states that phase is the average similarity between the waveform of a certain band in two locations over a period of time. The similarities between two waveforms are conceptualized as the strength of connections between two positions at a certain time period.

Shaw (1981) indicated that coherence could be considered a measure of the degree to which two signals at a given frequency maintain a phase-locked relationship over time. Regardless of the phase angle difference between the signals at a specific frequency, if the phase is constant, the coherence will be 1.0. If signals have an entirely random phase relationship, coherence will be 0. The degree to which a phase relationship is maintained over time between two signals of the same frequency at two locations in the cortex appears to be a measure of the extent to which they are either functionally linked, or working together to carry out some kind of processing task. As Shaw points out,

coherence is independent of the amplitude of the signals over the epochs considered, and dependent on their pattern of fluctuation.

Furthermore, phase measures the time at which one set of neurons fire and compares the time lag at which another set of neurons fire. Therefore, QEEG phase can often be used to compute the direction of coherence, that is, the direction that information flows from one electrode to another electrode (Thatcher, 2005). In addition, some researchers such as Hudspeth (1994) and Thornton (2002) have suggested that both QEEG phase and coherence are the best measures of connectivity.

Definition of Coherence

Coherence can be viewed as the correlation between two frequencies at two different sites in the brain. This suggests that two areas of the brain are functionally linked based on two common frequencies. However, other definitions of coherence have been proposed. Thatcher, Biver, McAlaster, Camacho, & Salazar (1998) defined coherence as the measure of phase synchrony or shared activity between spatially distant generators. Senf (1988) reported that the coordination of the signal between homologous signals, disregarding power, is a measure of coherence.

Shaw's (1981) description of coherence is similar to Senf's (1988) definition. Shaw indicated that QEEG coherence could be exhibited by correlation coefficients without concern for the strength of QEEG power. Shaw

further pointed out that coherence is the quantitative measure of the association between pairs of signals as a function of frequency. Hudspeth (1999) suggested that QEEG coherence should take into account functional space. Large distances between anatomical regions are expected to be hypocoherent and small distances between anatomical regions are expected to be hypercoherent. Thatcher (1992) indicated that QEEG coherence reflects the strength of synaptic connectivity between recording sites. He argued that high coherence indicates the integration of function and that low coherence indicates the differentiation of function.

Computations of coherence reflect correlation coefficients that have values varying between 0 and 1. High coherence correlation occurs during epileptic seizures, specifically occurring in 3 Hz wave discharges related to absence seizures. Low coherence correlation is associated with poor brain anatomical linkage, specifically following brain damage where cortical-cortical connections have been physically damaged (Thatcher, 1991).

Weiss & Mueller (2003) indicated that background noise defined in terms of uncorrelated activity of a group of neurons might occur sporadically or continuously in one or both signals in a coherence analysis. They explained that the phase between components in the two signals may alter over time. Therefore, phase needs to be taken into account in understanding the computation of coherence. Weiss & Mueller concluded that coherence could be interpreted as a stability measure of phase between the two simultaneously

recorded signals. Therefore, they suggest that high coherence is an indication of high cooperation and synchronization between the underlying summed potentials of a certain frequency band.

Neurofeedback (NF) is a clinical tool that influences coherence and amplitude in reducing pathological symptoms. Clinicians who use NF may train the communication or connectivity between regions (coherence training) or train the strength or amplitude of brain waves at specific sites (amplitude training). An important technical and clinical question is whether NF amplitude training alone produces changes in phase and coherence between cortical sites. This question was addressed in only one study to date (Ramezani, Bodenhamer-Davis, and Townsend, 2005). Researchers examined pre- and post-treatment QEEG phase and coherence scores (in frontal sites only) of subjects who received only amplitude training NF protocols. They found that amplitude training did not produce statistical significant changes in phase and coherence scores. However, most importantly, they found that effect sizes' for each individual electrode site were in the medium range, which indicates that true difference between pre and post phase and coherence scores existed. Furthermore, 85% of the abnormal pre-treatment phase and 72% of the abnormal pre-treatment coherence scores moved toward the reference database mean after NF amplitude training.

Recording with Referential and Sequential Montage

Electrical Potential Recording

In order to understand the true difference between referential and sequential electrode placements, a discussion related to the measurement of electrical activity would be helpful. Electrical activity can only be measured by comparison of QEEG activity at two sites. That is, an electric potential at one point only exists in reference to another electric potential. All electrical activity in QEEG represents a difference between two electric potentials that are dependent on each others' activity (Fehmi and Sundor, 1989).

Demos (2005) pointed out that in single-channel EEG biofeedback (neurofeedback) recording there are three electrodes used to measure electrical potential. An active electrode is placed on the scalp and measures cerebral electrical activity, and/or simply acquires QEEG data. A ground electrode is an inactive point used to complete a circuit. A reference electrode can be placed on either an inactive point or an active point in order to measure an electric potential. For example, the earlobe can be used as the reference (reference electrode used as inactive point) or the scalp can be used as the reference (reference electrode used as active point). The active QEEG recording, thus, is comprised of the difference in the QEEG signals registered at each of the two sites (active and reference or active and active).

Referential Placements

Referential placement utilizes one active electrode, one reference electrode, and one ground. Demos (2005) indicated that the active electrode is to be mounted on the scalp and the reference is regularly clipped to the earlobe, while the ground can be placed on the remaining earlobe. It is not uncommon to place the reference electrode in the same hemisphere as the active electrode. Demos further indicated that the major drawback of referential placement is its sensitivity to large amplitudes of electromyography (EMG) muscle artifact, such as facial movements and earlobe contamination. This is because referential placements lack common-mode rejection (Lubar, 1995), in which biofeedback signals that occur simultaneously in phase at different electrode inputs are rejected. For example, movement or cardiac artifact that occur above 60 Hz is rejected (Lubar, 1995). Referential placements yield absolute values of electrical potential. Since the active electrode is compared to a reference point, such as the earlobe, which is assumed to have approximately zero potential value, the electrical potential that is recorded is theoretically an absolute value of the active electrode (Demos, 2005; Lubar, 1995).

Sequential Placements

Sequential placements utilize two active and one ground electrode. In this method, the reference electrode is used as an active point. The sequential placement may be connected going from front to back (longitudinal) or from left

to right (transverse). Demos (2005) points out that since the two active electrodes are placed on the scalp while the ground is placed on the earlobe, there should be a measure of impedance that confirms that the resistance of both active electrodes is similar.

The sequential placement will not yield absolute values. Since the reference electrode is used as a second active electrode, then it has a relative electric potential value. Explicitly, the reference point does not have an approximate zero potential value (Demos, 2005; Lubar, 1995). The sequential placements will yield incremental values that demonstrate the difference between the two active electrodes.

Fehmi and Sundor (1989) point out the difficulty in observing brain wave activity when two in-phase and equal amplitude waves are recorded with sequential placements. As mentioned before, a measurement of voltage refers to the difference between two electrical potentials. However, if the electrical potential at two active electrodes fluctuate in phase and have equal amplitude with respect to an inactive point, then, because of common mode rejection, the EEG will show no fluctuation in voltage (Fehmi and Sundor, 1989). In other words, an oscilloscope would show a flat trace or a straight line. The tracing may indicate two equal amplitude, in-phase electrical activities, or brain death. Conversely, with referential placements, the accuracy of amplitude measurement is preserved.

It may appear that it makes little difference whether the reference electrode is used as an inactive point or an active point. However, in NF training, the manipulation of the reference electrode can be conceptualized as training the connectivity in addition to training the amplitude of the brain wave between two active electrodes. This implies that the use of the reference electrode as an active point (sequential placement) may change connectivity as well as changing the amplitude of the brain waves being trained. Some researchers have suggested such an effect (Lubar, 1995; Demos, 2005).

Lubar (1995) raised a fundamental question related to QEEG recordings: “It would be instructive to compare a controlled study with matched groups in which one group receives monopolar recording and the other receives bipolar training to see if there is any significant difference between the two” (p. 509). Lubar suggests that sequential or bipolar training may have different effects on cerebral regions when compared to referential or monopolar training.

Other researchers have suggested that sequential training may work to change the connectivity or communication between cerebral sites. Demos (2005) also raised a similar question and hypothesized that communication between the two active electrodes may be enhanced in sequential training. He stated, “Another factor relates to communication: bipolar montages engage two regions of the brain simultaneously. Hence, two separate regions are conscripted into the same neuronal task” (p.74). Both Lubar (1995) and Demos suggest that

sequential and referential amplitude training may have different effects on cerebral sites. However, there is no empirical evidence for this hypothesis.

Purpose

The aim of this study is to answer the research question of whether referential NF amplitude training and sequential NF amplitude training have different effects on phase and coherence measures of brain connectivity. The study investigates whether amplitude training causes a shift in brain function that allows for an overall reorganization of neuronal networks. If coherence is defined as the relationship between two regions, independent of power or amplitude, then does NF amplitude training effect coherence measures? On the one hand, amplitude training may not change connectivity or develop pathways between cerebral sites. In this case, the cerebral area under the electrode site that receives amplitude training may be the only area that will change independent of the other electrodes. On the other hand, amplitude training may work to cause a shift in the brain activity that results in changes in connectivity between regions of the brain, or, in other words, a reorganization of brain activity.

The issue that this study attempts to clarify is whether referential placements and sequential placements have different effects on QEEG connectivity measures of phase and coherence. Four hypotheses have been made. First, this study hypothesizes that following NF amplitude training there will be a difference in QEEG phase scores between subjects who have received

primarily referential placement training and subjects who have received primarily sequential placement training. The second hypothesis states that at least 50% of the QEEG phase abnormalities will move toward the reference database mean following NF amplitude training. The third hypothesis states that following NF amplitude training there will be a difference in QEEG coherence measures between subjects who have received primarily referential placement training and subjects who have received primarily sequential placement training. The fourth hypothesis states that at least 50% of the QEEG coherence abnormalities will move toward the reference database mean following NF amplitude training.

CHAPTER 2

METHOD

Participants

Archival files of individuals who completed Electroencephalograph (EEG) biofeedback at the Neurotherapy Lab at the University of North Texas were examined. All files selected for analysis contained the following: pre- and post-treatment eyes-open quantitative-electroencephalograph (QEEG) recording, amplitude training NF only (no coherence or phase synchrony training), and fewer than 50 training sessions. Individual case files had a minimum of 21 and a maximum of 50 NF sessions.

Apparatus and Measurement

QEEG Recording

QEEG data used in this study was recorded from nineteen sites using the International 10-20 system, using Lexicor Neurosearch-24. A linked-ear reference was used for all recordings. All data were collected under eyes closed and eyes open conditions. All impedances were kept under 5 k ohms.

QEEG Coherence & Phase Computation

The Lexicor data files were converted to NeuroGuide 2.2.5 (Thatcher, 2005) data files to compute coherence measures. A linked-ear reference was

selected in NeuroGuide 2.2.5. NeuroGuide 2.2.5 computes phase and coherence in the frequency range of 1-25.0 Hz between 15 sites. QEEG frequency domains were filtered into delta (1.0-3.5 Hz), theta (4.0-7.5 Hz), alpha (8.0-12 Hz), and beta (12.5-25.0 Hz). In order to reduce Type I error this analysis included only the six frontal sites for the interpretation. The analysis included inter-hemispheric connections of Fp1-Fp2, F3-F4, and F7-F8, and intra-hemisphere connections of Fp1-F3, Fp1-F7, F3-F7, Fp2-F4, Fp2-F8, and F4-F8.

Treatment Method

NF protocols varied with each subject based on their pre-treatment QEEG. Subject files were divided into two groups: those who received referential montage amplitude training and those who received sequential montage amplitude training.

Statistical Analysis

Subjects' pre- and post- treatment phase and coherence *z*-scores were derived using the report option in NeuroGuide 2.2.5. Pre-treatment phase and coherence *z*-scores greater than 1 *SD* were classified as abnormal scores and were selected as sites to be analyzed. The pre- and post- treatment phase and coherence *z*-scores were entered into SPSS 11.0 for general linear model analysis. Due to *z*-scores having a positive or negative sign, true difference could be masked by mean comparisons. Therefore, abnormal phase and

coherence *z*-scores were transformed into deviation scores by taking the absolute value of the score minus its mean for every site. To determine the effect of referential and sequential montage amplitude training on connectivity measures, first, a general linear model analysis of variance function (similar to a t-test function) in SPSS was used to compare pre-treatment deviation scores in order to determine whether subjects who received referential placements and those who received sequential placements were similar before NF amplitude training. Second, another general linear model analysis of variance function in SPSS was used to compare post-treatment deviation scores for the subjects who received referential placements to subjects who received sequential placements. Percentages of abnormal sites that moved toward or deviated from the reference database were also calculated. Due to the small sample size, this study lacks the statistical power needed to identify a significant difference using *p*-value. Therefore, effect sizes and eta squares were calculated to determine the magnitude of the difference between referential and sequential placement groups.

CHAPTER 3

RESULTS

Sixteen subjects' quantitative-electroencephalograph (QEEG) records were compared on pre-NF treatment referential and sequential measures of phase and coherence (Pre-treatment analysis). Only frontal lobe electrode sites in QEEG maps were analyzed. General linear model analysis of variance function was used to compare pre-treatment referential phase and coherence deviation scores to pre-treatment sequential phase and coherence deviation scores. In addition, subjects' QEEG records were compared on post-NF treatment referential and sequential measures of phase and coherence (Post-treatment analysis). Another general linear model analysis of variance function was used to compare post-treatment referential phase and coherence deviation scores to post-treatment sequential phase and coherence deviation scores. The percentages of abnormal sites of phase and coherence measures that either deviated from the reference database mean or moved towards the reference database mean (norms from NeuroGuide 2.2.5) were calculated for both the referential group and the sequential group.

Pre-treatment Analysis of Referential Versus Sequential Placements

In order to reduce Type I error, Bonferroni *p*-value adjustment was calculated based on 5% error. The adjusted alpha level for the phase and coherence measures was 0.001. Using a general linear model, analysis of variance showed that there was no significant difference between referential and sequential placement groups on pre-treatment phase and coherence measures, F (14, 1) = 0.50, $p > .05$. The significance test showed that the two montage placement groups are similar before NF amplitude training. However, further observation of individual frontal lobe site values revealed that more than half of the effect size r-values showed a large effect size, indicating that there was a difference between referential and sequential placement groups before NF amplitude training. The difference between deviation score means is also apparent in Figure 1 and Figure 2.

Pre-treatment Difference Between Referential and Sequential Placements on Phase Measures

Delta Frequency Analysis

Referential versus sequential placement phase values in the delta frequency showed no statistically significant difference for the following sites:

FP1-FP2 [F (1, 14) = 0.627, $p > .05$, effect size r = 0.207, partial eta square = 0.043]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect

size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 4% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F3 [*F* (1, 14) = 2.932, *p* > .05, effect size *r* = 0.416, partial eta square = 0.173]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 17% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F7 [*F* (1, 14) = 0.020, *p* > .05, effect size *r* = 0.038, partial eta square =0.002]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 0.2% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F4 [*F* (1, 14) = 2.830, *p* > .05, effect size *r* = 0.410, partial eta square =0.169]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 17% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F8 [*F* (1, 14) = 0.012, *p* > .05, effect size *r* = 0.029, partial eta square =0.001]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 0.1% of the variance in phase scores can be accounted for by the electrode placements.

F3-F4 [*F* (1, 14) = 1.614, *p* > .05, effect size *r* = 0.321, partial eta square = 0.103]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on phase scores. The eta squared suggests that 10% of the variance in phase scores can be accounted for by the electrode placements

F3-F7 [*F* (1, 14) = 2.61, *p* > .05, effect size *r* = 0.400, partial eta square = 0.157]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 16% of the variance in phase scores can be accounted for by the electrode placements.

F4-F8 [*F* (1, 14) = 0.260, *p* > .05, effect size *r* = 0.135, partial eta square = 0.018]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase

scores. The eta squared suggests that 2% of the variance in phase scores can be accounted for by the electrode placements.

F7-F8 [*F* (1, 14) = 2.154, *p* > .05, effect size *r* = 0.365, partial eta square = 0.133]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 13% of the variance in phase scores can be accounted for by the electrode placements.

Theta Frequency Analysis

Referential versus sequential placement phase values in the theta frequency did not reach statistical significance for the following sites:

FP1-FP2 [*F* (1, 14) = 0.50, *p* > .05, effect size *r* = 0.187, partial eta square = 0.035]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 4% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F3 [*F* (1, 14) = 0.477, *p* > .05, effect size *r* = 0.181, partial eta square =0.033]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential

groups on phase scores. The eta squared suggests that 3% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F7 [*F* (1, 14) = 0.355, *p* > .05, effect size *r* = 0.157, partial eta square = 0.025]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 3% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F4 [*F* (1, 14) = 1.271, *p* > .05, effect size *r* = 0.289, partial eta square = 0.083].This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on phase scores. The eta squared suggests that 8% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F8 [*F* (1, 14) = 2.153, *p* > .05, effect size *r* = 0.365, partial eta square = 0.133]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on phase scores. The eta squared suggests that 13% of the variance in phase scores can be accounted for by the electrode placements.

F3-F4 [*F* (1, 14) = 0.375, *p* > .05, effect size *r* = 0.161, partial eta square = 0.026]. This site showed a small effect size, which indicates that the standardized

difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 3% of the variance in phase scores can be accounted for by the electrode placements.

F3-F7 [F (1, 14) = 0.115, p > .05, effect size r = 0.090, partial eta square = 0.008]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 0.8% of the variance in phase scores can be accounted for by the electrode placements.

F4-F8 [F (1, 14) = 0.729, p > .05, effect size r = 0.223, partial eta square = 0.050]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 5% of the variance in phase scores can be accounted for by the electrode placements.

F7-F8 [F (1, 14) = 0.033, p > .05, effect size r = 0.049, partial eta square = 0.002]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 0.2% of the variance in phase scores can be accounted for by the electrode placements.

Alpha Frequency Analysis

No significant difference was found between referential and sequential placement on phase measures in the alpha frequency for the following sites:

FP1-FP2 [F (1, 14) = 5.973, p > .05, effect size r = 0.547, partial eta square = 0.299]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 30% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F3 [F (1, 14) = 2.156, p > .05, effect size r = 0.365, partial eta square = 0.133]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on phase scores. The eta squared suggests that 13% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F7 [F (1, 14) = 0.384, p > .05, effect size r = 0.163, partial eta square = 0.027]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 3% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F4 [*F* (1, 14) = 1.730, *p* > .05, effect size *r* = 0.332, partial eta square = 0.110]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on phase scores. The eta squared suggests that 11% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F8 [*F* (1, 14) = 1.994, *p* > .05, effect size *r* = 0.353, partial eta square = 0.125]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on phase scores. The eta squared suggests that 13% of the variance in phase scores can be accounted for by the electrode placements.

F3-F4 [*F* (1, 14) = 0.905, *p* > .05, effect size *r* = 0.246, partial eta square = 0.061]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on phase scores. The eta squared suggests that 6% of the variance in phase scores can be accounted for by the electrode placements.

F3-F7 [*F* (1, 14) = 1.156, *p* > .05, effect size *r* = 0.276, partial eta square = 0.076]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and

sequential groups on phase scores. The eta squared suggests that 7% of the variance in phase scores can be accounted for by the electrode placements.

F4-F8 [F (1, 14) = 0.074, p > .05, effect size r = 0.072, partial eta square = 0.005]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 0.5% of the variance in phase scores can be accounted for by the electrode placements.

F7-F8 [F (1, 14) = 0.152, p > .05, effect size r = 0.104, partial eta square = 0.010]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 1% of the variance in phase scores can be accounted for by the electrode placements.

Beta Frequency Analysis

Referential versus sequential placement phase values in the beta frequency showed no statistically significant difference for the following sites:

FP1-FP2 [F (1, 14) = 6.076, p > .05, effect size r = 0.550, partial eta square = 0.303]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential

groups on phase scores. The eta squared suggests that 30% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F3 [F (1, 14) = 6.058, p > .05, effect size r = 0.550, partial eta square = 0.302]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 30% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F7 [F (1, 14) = 5.216, p > .05, effect size r = 0.521, partial eta square = 0.271]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 27% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F4 [F (1, 14) = 1.456, p > .05, effect size r = 0.307, partial eta square = 0.094]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on phase scores. The eta squared suggests that 9% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F8 [F (1, 14) = 1.666, p > .05, effect size r = 0.326, partial eta square = 0.106]. This site showed a medium effect size, which indicates that the

standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on phase scores. The eta squared suggests that 11% of the variance in phase scores can be accounted for by the electrode placements.

F3-F4 [F (1, 14) = 3.694, p > .05, effect size r = 0.457, partial eta square = 0.209]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 21% of the variance in phase scores can be accounted for by the electrode placements.

F3-F7 [F (1, 14) = 0.727, p > .05, effect size r = 0.222, partial eta square = 0.049]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 5% of the variance in phase scores can be accounted for by the electrode placements.

F4-F8 [F (1, 14) = 0.663, p > .05, effect size r = 0.213, partial eta square = 0.045]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 5% of the variance in phase scores can be accounted for by the electrode placements.

F7-F8 [F (1, 14) = 2.946, p > .05, effect size r = 0.417, partial eta square = 0.174]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 17% of the variance in phase scores can be accounted for by the electrode placements.

Inferential statistic findings can be viewed on Table 17. Table 1 and Table 2 summarize the means and standard deviation of deviation scores for pre-treatment referential and sequential placement. Table 9 and Table 10 summarize the means and standard deviation of *z*-scores for pre-treatment referential and sequential placement.

Pre-treatment Difference Between Referential and Sequential Placements on Coherence Measures

Delta Frequency Analysis

No significant difference was found between referential and sequential placement on coherence measures in the delta frequency for the following sites:

FP1-FP2 [F (1, 14) = 3.4573, p > .05, effect size r = 0.445, partial eta square = 0.1980]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential

groups on coherence scores. The eta squared suggests that 20% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F3 [F (1, 14) = 3.2382, p > .05, effect size r = 0.433, partial eta square = 0.1879]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on coherence scores. The eta squared suggests that 19% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F7 [F (1, 14) = 3.2382, p > .05, effect size r = 0.381, partial eta square = 0.1450]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on coherence scores. The eta squared suggests that 15% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F4 [F (1, 14) = 0.8059, p > .05, effect size r = 0.233, partial eta square = 0.0544]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 5% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F8 [F (1, 14) = 0.4245, p > .05, effect size r = 0.172, partial eta square = 0.0294]. This site showed a small effect size, which indicates that the

standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 3% of the variance in phase scores can be accounted for by the electrode placements.

F3-F4 [F (1, 14) = 6.0141, p > .05, effect size r = 0.548, partial eta square = 0.3005]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on coherence scores. The eta squared suggests that 30% of the variance in phase scores can be accounted for by the electrode placements.

F3-F7 [F (1, 14) = 2.6796, p > .05, effect size r = 0.401, partial eta square = 0.1607]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on coherence scores. The eta squared suggests that 16% of the variance in phase scores can be accounted for by the electrode placements.

F4-F8 [F (1, 14) = 4.3057, p > .05, effect size r = 0.485, partial eta square = 0.2352]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on coherence scores. The eta squared suggests that 24% of the variance in phase scores can be accounted for by the electrode placements.

F7-F8 [*F* (1, 14) = 1.0512, *p* > .05, effect size *r* = 0.264, partial eta square = 0.0698]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 7% of the variance in phase scores can be accounted for by the electrode placements.

Theta Frequency Analysis

Referential versus sequential placement coherence changes in the theta frequency did not reach statistical significance for the following sites:

FP1-FP2 [*F* (1, 14) = 2.365, *p* > .05, effect size *r* = 0.380, partial eta square = 0.145]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on coherence scores. The eta squared suggests that 15% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F3 [*F* (1, 14) = 3.274, *p* > .05, effect size *r* = 0.435, partial eta square = 0.190]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on coherence scores. The eta squared suggests that 19% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F7 [*F* (1, 14) = 0.131, *p* > .05, effect size *r* = 0.096, partial eta square = 0.009]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.9% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F4 [*F* (1, 14) = 0.466, *p* > .05, effect size *r* = 0.180, partial eta square = 0.032]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 3% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F8 [*F* (1, 14) = 0.297, *p* > .05, effect size *r* = 0.144, partial eta square = 0.021]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 2% of the variance in phase scores can be accounted for by the electrode placements.

F3-F4 [*F* (1, 14) = 2.348, *p* > .05, effect size *r* = 0.379, partial eta square = 0.14]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on

coherence scores. The eta squared suggests that 14% of the variance in phase scores can be accounted for by the electrode placements.

F3-F7 [F (1, 14) = 1.385, p > .05, effect size r = 0.300, partial eta square = 0.090]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on coherence scores. The eta squared suggests that 9% of the variance in phase scores can be accounted for by the electrode placements.

F4-F8 [F (1, 14) = 0.668, p > .05, effect size r = 0.213, partial eta square = 0.046]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 5% of the variance in phase scores can be accounted for by the electrode placements.

F7-F8 [F (1, 14) = 0.282, p > .05, effect size r = 0.140, partial eta square = 0.020]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 2% of the variance in phase scores can be accounted for by the electrode placements.

Alpha Frequency Analysis

Referential versus sequential placement coherence values in the alpha frequency showed no statistical significant difference for the following sites:

FP1-FP2 [F (1, 14) = 0.021, p > .05, effect size r = 0.039, partial eta square = 0.001]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.1% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F3 [F (1, 14) = 1.535, p > .05, effect size r = 0.314, partial eta square = 0.098]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on coherence scores. The eta squared suggests that 10% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F7 [F (1, 14) = 0.176, p > .05, effect size r = 0.112, partial eta square = 0.012]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 1% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F4 [*F* (1, 14) = 2.597, *p* > .05, effect size *r* = 0.396, partial eta square = 0.156]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on coherence scores. The eta squared suggests that 16% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F8 [*F* (1, 14) = 0.002, *p* > .05, effect size *r* = 0.012, partial eta square = 0.0001]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.001% of the variance in phase scores can be accounted for by the electrode placements.

F3-F4 [*F* (1, 14) = 0.371, *p* > .05, effect size *r* = 0.161, partial eta square = 0.026]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 3% of the variance in phase scores can be accounted for by the electrode placements.

F3-F7 [*F* (1, 14) = 0.510, *p* > .05, effect size *r* = 0.187, partial eta square = 0.035]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on

coherence scores. The eta squared suggests that 4% of the variance in phase scores can be accounted for by the electrode placements.

F4-F8 [*F* (1, 14) = 0.646, *p* > .05, effect size *r* = 0.210, partial eta square = 0.044]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 4% of the variance in phase scores can be accounted for by the electrode placements.

F7-F8 [*F* (1, 14) = 0.742, *p* > .05, effect size *r* = 0.224, partial eta square = 0.050]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 5% of the variance in phase scores can be accounted for by the electrode placements.

Beta Frequency Analysis

Referential versus sequential placement coherence values in the beta frequency showed no statistical significant difference for the following sites:

FP1-FP2 [*F* (1, 14) = 0.182, *p* > .05, effect size *r* = 0.113, partial eta square = 0.0128]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential

groups on coherence scores. The eta squared suggests that 1% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F3 [F (1, 14) = 0.013, p > .05, effect size r = 0.031, partial eta square = 0.0010]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.1% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F7 [F (1, 14) = 0.992, p > .05, effect size r = 0.257, partial eta square = 0.0662]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on coherence scores. The eta squared suggests that 7% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F4 [F (1, 14) = 0.002, p > .05, effect size r = 0.012, partial eta square = 0.0001]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.01% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F8 [F (1, 14) = 0.723, p > .05, effect size r = 0.222, partial eta square = 0.0491]. This site showed a small effect size, which indicates that the

standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 5% of the variance in phase scores can be accounted for by the electrode placements.

F3-F4 [F (1, 14) = 1.575, p > .05, effect size r = 0.318, partial eta square = 0.1011]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on coherence scores. The eta squared suggests that 10% of the variance in phase scores can be accounted for by the electrode placements.

F3-F7 [F (1, 14) = 0.0008, p > .05, effect size r = 0.007, partial eta square = 0.0001]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.01% of the variance in phase scores can be accounted for by the electrode placements.

F4-F8 [F (1, 14) = 0.0005, p > .05, effect size r = 0.006, partial eta square = 0.0000]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.00% of the variance in phase scores can be accounted for by the electrode placements.

F7-F8 [F (1, 14) = 0.036, p > .05, effect size r = 0.157, partial eta square = 0.025]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 3% of the variance in phase scores can be accounted for by the electrode placements.

Inferential statistic findings can be viewed on Table 18. Table 3 and Table 4 summarize the means and standard deviation of deviation scores for pre-treatment referential and sequential placement. Table 11 and Table 12 summarize the means and standard deviation of *z*-scores for pre-treatment referential and sequential placement.

Post-treatment Analysis of Referential Versus Sequential Placements

Bonferroni p-value adjustment was calculated based on 5 % error. The adjusted alpha level for phase and coherence measures was 0.001. Overall, post-treatment referential and sequential placement changes in phase and coherence did not reach statistical significance. Using a general linear model, analysis of variance showed that there are no significant difference between referential and sequential placement groups on post-treatment phase and coherence measures, F (14, 1) = 0.449, p > .05. Significance test show that the two montage placement groups are not significantly different after NF amplitude training. However, most effect size r-values showed a medium to large effect

size. This indicates that true difference between referential and sequential placements after NF amplitude training exist. The difference between deviation score means is also evident in Figure 1 and Figure 2.

The Effects of Referential Versus Sequential Placements on Phase Measures

Delta Frequency Analysis

Referential versus sequential placement phase values in the delta frequency showed no statistically significant difference for the following sites:

FP1-FP2 [F (1, 14) = 0.101, p > .05, effect size r = 0.085, partial eta square = 0.007]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 0.7% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F3 [F (1, 14) = 0.102, p > .05, effect size r = 0.085, partial eta square = 0.007]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 0.7% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F7 [*F* (1, 14) = 2.540, *p* > .05, effect size *r* = 0.392, partial eta square = 0.154]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 15% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F4 [*F* (1, 14) = 0.318, *p* > .05, effect size *r* = 0.149, partial eta square = 0.022]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 2% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F8 [*F* (1, 14) = 0.404, *p* > .05, effect size *r* = 0.167, partial eta square = 0.028]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 3% of the variance in phase scores can be accounted for by the electrode placements.

F3-F4 [*F* (1, 14) = 0.551, *p* > .05, effect size *r* = 0.195, partial eta square = 0.038]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase

scores. The eta squared suggests that 4% of the variance in phase scores can be accounted for by the electrode placements.

F3-F7 [F (1, 14) = 0.758, p > .05, effect size r = 0.227, partial eta square = 0.051]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 5% of the variance in phase scores can be accounted for by the electrode placements.

F4-F8 [F (1, 14) = 0.100, p > .05, effect size r = 0.084, partial eta square = 0.007]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 0.07% of the variance in phase scores can be accounted for by the electrode placements.

F7-F8 [F (1, 14) = 0.200, p > .05, effect size r = 0.119, partial eta square = 0.014]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 14% of the variance in phase scores can be accounted for by the electrode placements.

Theta Frequency Analysis

Referential versus sequential placement phase differences in the theta frequency did not reach statistical significance for the following sites:

FP1-FP2 [F (1, 14) = 1.07, p > .05, effect size r = 0.266, partial eta square = 0.071]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on phase scores. The eta squared suggests that 7% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F3 [F (1, 14) = 1.729, p > .05, effect size r = 0.332, partial eta square = 0.110]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on phase scores. The eta squared suggests that 11% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F7 [F (1, 14) = 0.145, p > .05, effect size r = 0.101, partial eta square = 0.010]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 1% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F4 [*F* (1, 14) = 4.479, *p* > .05, effect size *r* = 0.492, partial eta square = 0.242]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 24% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F8 [*F* (1, 14) = 0.351, *p* > .05, effect size *r* = 0.156, partial eta square = 0.025]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 3% of the variance in phase scores can be accounted for by the electrode placements.

F3-F4 [*F* (1, 14) = 1.004, p > .05, effect size *r* = 0.259, partial eta square = 0.067]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on phase scores. The eta squared suggests that 7% of the variance in phase scores can be accounted for by the electrode placements.

F3-F7 [*F* (1, 14) = 1.313, *p* > .05, effect size *r* = 0.293, partial eta square = 0.086]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and

sequential groups on phase scores. The eta squared suggests that 9% of the variance in phase scores can be accounted for by the electrode placements.

F4-F8 [*F* (1, 14) = 5.497, *p* > .05, effect size *r* = 0.531, partial eta square = 0.280]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 28% of the variance in phase scores can be accounted for by the electrode placements.

F7-F8 [*F* (1, 14) = 0.001, *p* > .05, effect size *r* = 0.006, partial eta square = 0.0001]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 0.01% of the variance in phase scores can be accounted for by the electrode placements.

Alpha Frequency Analysis

No significant difference was found between referential and sequential placement on phase measures in the alpha frequency for the following sites:

FP1-FP2 [*F* (1, 14) = 1.2753, *p* > .05, effect size *r* = 0.289, partial eta square = 0.084]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and

sequential groups on phase scores. The eta squared suggests that 8% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F3 [F (1, 14) = 0.704, p > .05, effect size r = 0.219, partial eta square = 0.048]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 5% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F7 [F (1, 14) = 0.001, p > .05, effect size r = 0.008, partial eta square = 0.0001]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 0.01% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F4 [F (1, 14) = 0.156, p > .05, effect size r = 0.105, partial eta square = 0.011]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on phase scores. The eta squared suggests that 1% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F8 [F (1, 14) = 0.840, p > .05, effect size r = 0.238, partial eta square = 0.057]. This site showed a small effect size, which indicates that the

standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 6% of the variance in phase scores can be accounted for by the electrode placements.

F3-F4 [F (1, 14) = 3.025, p > .05, effect size r = 0.422, partial eta square = 0.178]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 18% of the variance in phase scores can be accounted for by the electrode placements.

F3-F7 [F (1, 14) = 0.035, p > .05, effect size r = 0.050, partial eta square = 0.003]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.3% of the variance in phase scores can be accounted for by the electrode placements.

F4-F8 [F (1, 14) = 1.390, p > .05, effect size r = 0.301, partial eta square = 0.090]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on coherence scores. The eta squared suggests that 9% of the variance in phase scores can be accounted for by the electrode placements.

F7-F8 [*F* (1, 14) = 0.056, *p* > .05, effect size *r* = 0.063, partial eta square = 0.004]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.4% of the variance in phase scores can be accounted for by the electrode placements.

Beta Frequency Analysis

Referential versus sequential placement phase values in the beta frequency showed no statistically significant difference for the following sites:

FP1-FP2 [*F* (1, 14) = 0.330, *p* > .05, effect size *r* = 0.152, partial eta square = 0.0231]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 2% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F3 [*F* (1, 14) = 0.597, *p* > .05, effect size *r* = 0.202, partial eta square = 0.0409]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 4% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F7 [*F* (1, 14) = 2.898, *p* > .05, effect size *r* = 0.414, partial eta square = 0.1715]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 17% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F4 [*F* (1, 14) = 0.931, *p* > .05, effect size *r* = 0.250, partial eta square = 0.062]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on coherence scores. The eta squared suggests that 6% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F8 [*F* (1, 14) = 0.496, *p* > .05, effect size *r* = 0.185, partial eta square = 0.034]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 3% of the variance in phase scores can be accounted for by the electrode placements.

F3-F4 [*F* (1, 14) = 0.864, *p* > .05, effect size *r* = 0.241, partial eta square = 0.058]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and

sequential groups on coherence scores. The eta squared suggests that 6% of the variance in phase scores can be accounted for by the electrode placements.

F3-F7 [F (1, 14) = 0.0001, p > .05, effect size r = 0.002, partial eta square = 0.0001]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.01% of the variance in phase scores can be accounted for by the electrode placements.

F4-F8 [F (1, 14) = 0.349, p > .05, effect size r = 0.156, partial eta square = 0.024]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 2% of the variance in phase scores can be accounted for by the electrode placements.

F7-F8 [F (1, 14) = 0.199, p > .05, effect size r = 0.118, partial eta square = 0.014]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.1% of the variance in phase scores can be accounted for by the electrode placements.

Inferential statistic findings can be viewed on Table 19. Table 5 and Table 6 summarize the means and standard deviation of deviation scores for pre-

treatment referential and sequential placement. Table 13 and Table 14 summarize the means and standard deviation of *z-score*s for pre-treatment referential and sequential placement.

The Effects of Referential Versus Sequential Placements on Coherence Measures

Delta Frequency Analysis

Referential versus sequential placement coherence differences in the delta frequency did not reach statistical significance for the following sites:

FP1-FP2 [F (1, 14) = 2.9720, p > .05, effect size r = 0.418, partial eta square = 0.1751]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 18% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F3 [F (1, 14) = 0.0412, p > .05, effect size r = 0.054, partial eta square = 0.0029]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.3% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F7 [*F* (1, 14) = 0.4181, *p* > .05, effect size *r* = 0.170, partial eta square = 0.0290]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 3% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F4 [*F* (1, 14) = 0.1629, p > .05, effect size r = 0.107, partial eta square = 0.0115]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 1% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F8 [*F* (1, 14) = 1.3479, *p* > .05, effect size *r* = 0.296, partial eta square = 0.0878]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on coherence scores. The eta squared suggests that 9% of the variance in phase scores can be accounted for by the electrode placements.

F3-F4 [*F* (1, 14) = 0.0695, *p* > .05, effect size *r* = 0.070, partial eta square = 0.0049]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential

groups on coherence scores. The eta squared suggests that 0.5% of the variance in phase scores can be accounted for by the electrode placements.

F3-F7 [F (1, 14) = 2.8989, p > .05, effect size r = 0.414, partial eta square = 0.1715]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 17% of the variance in phase scores can be accounted for by the electrode placements.

F4-F8 [F (1, 14) = 2.1429, p > .05, effect size r = 0.364, partial eta square = 0.1327]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 13% of the variance in phase scores can be accounted for by the electrode placements.

F7-F8 [F (1, 14) = 2.4235, p > .05, effect size r = 0.384, partial eta square = 0.1476].This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 15% of the variance in phase scores can be accounted for by the electrode placements.

Theta Frequency Analysis

No significant difference was found between referential and sequential placement on coherence measures in the theta frequency for the following sites:

FP1-FP2 [F (1, 14) = 2.1929, p > .05, effect size r = 0.368, partial eta square = 0.1354]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 14% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F7 [F (1, 14) = 0.3788, p > .05, effect size r = 0.162, partial eta square = 0.0263]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 3% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F4 [F (1, 14) = 3.2974, p > .05, effect size r = 0.437, partial eta square = 0.1906]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 19% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F8 [*F* (1, 14) = 0.0280, *p* > .05, effect size *r* = 0.045, partial eta square = 0.0020]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.2% of the variance in phase scores can be accounted for by the electrode placements.

F3-F4 [*F* (1, 14) = 0.0193, *p* > .05, effect size *r* = 0.037, partial eta square = 0.0014]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.1% of the variance in phase scores can be accounted for by the electrode placements.

F3-F7 [*F* (1, 14) = 1.0719, *p* > .05, effect size *r* = 0.267, partial eta square = 0.0711]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on coherence scores. The eta squared suggests that 7% of the variance in phase scores can be accounted for by the electrode placements.

F4-F8 [*F* (1, 14) = 2.8509, *p* > .05, effect size *r* = 0.411, partial eta square = 0.1692]. This site showed a large effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential

groups on phase scores. The eta squared suggests that 17% of the variance in phase scores can be accounted for by the electrode placements.

F7-F8 [*F* (1, 14) = 0.0032, *p* > .05, effect size *r* = 0.015, partial eta square = 0.0002]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.02% of the variance in phase scores can be accounted for by the electrode placements.

The only site that showed statistical significant difference between referential and sequential placements on coherence measures was FP1-F3 [*F* (1, 14) = 17.300, *p* < .05, effect size *r* = 0.743, partial eta square = 0.5527]. This site showed the larges effect size, which indicates that the standardized difference between the two means is high. In addition, this effect size shows that there is a large correlation between referential and sequential groups on phase scores. The eta squared suggests that 55% of the variance in phase scores can be accounted for by the electrode placements.

Alpha Frequency Analysis

Referential versus sequential placement coherence changes in the alpha frequency showed no statistical significant difference for the following sites:

FP1-FP2 [*F* (1, 14) = 0.1017, *p* > .05, effect size *r* = 0.085, partial eta square = 0.0072]. This site showed a small effect size, which indicates that the

standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.7% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F3 [F (1, 14) = 0.7465, p > .05, effect size r = 0.225, partial eta square = 0.0506]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 5% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F7 [F (1, 14) = 0.0111, p > .05, effect size r = 0.028, partial eta square = 0.0008]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.08% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F4 [F (1, 14) = 0.0887, p > .05, effect size r = 0.079, partial eta square = 0.0063]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.6% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F8 [*F* (1, 14) = 0.4472, *p* > .05, effect size *r* = 0.176, partial eta square = 0.0310]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 3% of the variance in phase scores can be accounted for by the electrode placements.

F3-F4 [*F* (1, 14) = 0.0645, *p* > .05, effect size *r* = 0.068, partial eta square = 0.0046]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.5% of the variance in phase scores can be accounted for by the electrode placements.

F3-F7 [*F* (1, 14) = 0.0009, *p* > .05, effect size *r* = 0.008, partial eta square = 0.0001]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.01% of the variance in phase scores can be accounted for by the electrode placements.

F4-F8 [*F* (1, 14) = 0.1187, *p* > .05, effect size *r* = 0.092, partial eta square = 0.0084]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential

groups on coherence scores. The eta squared suggests that 0.8% of the variance in phase scores can be accounted for by the electrode placements.

F7-F8 [*F* (1, 14) = 0.0541, *p* > .05, effect size *r* = 0.062, partial eta square = 0.0038]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.4% of the variance in phase scores can be accounted for by the electrode placements.

Beta Frequency Analysis

No significant difference was found between referential and sequential placement on coherence measures in the beta frequency for the following sites:

FP1-FP2 [*F* (1, 14) = 1.2382, *p* > .05, effect size *r* = 0.285, partial eta square = 0.0813]. This site showed a medium effect size, which indicates that the standardized difference between the two means is moderate. In addition, this effect size shows that there is a medium correlation between referential and sequential groups on coherence scores. The eta squared suggests that 8% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F3 [*F* (1, 14) = 0.3098, *p* > .05, effect size *r* = 0.147, partial eta square = 0.0217]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential

groups on coherence scores. The eta squared suggests that 2% of the variance in phase scores can be accounted for by the electrode placements.

FP1-F7 [F (1, 14) = 0.0290, p > .05, effect size r = 0.046, partial eta square = 0.0021]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.2% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F4 [F (1, 14) = 0.0065, p > .05, effect size r = 0.022, partial eta square = 0.0005]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.05% of the variance in phase scores can be accounted for by the electrode placements.

FP2-F8 [F (1, 14) = 0.0313, p > .05, effect size r = 0.047, partial eta square = 0.0022]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.2% of the variance in phase scores can be accounted for by the electrode placements.

F3-F4 [F (1, 14) = 0.1235, p > .05, effect size r = 0.093, partial eta square = 0.0087]. This site showed a small effect size, which indicates that the

standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.9% of the variance in phase scores can be accounted for by the electrode placements.

F3-F7 [F (1, 14) = 0.5854, p > .05, effect size r = 0.200, partial eta square = 0.0401]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 4% of the variance in phase scores can be accounted for by the electrode placements.

F4-F8 [F (1, 14) = 0.3995, p > .05, effect size r = 0.167, partial eta square = 0.0277]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 3% of the variance in phase scores can be accounted for by the electrode placements.

F7-F8 [F (1, 14) = 0.0188, p > .05, effect size r = 0.037, partial eta square = 0.0013]. This site showed a small effect size, which indicates that the standardized difference between the two means is low. In addition, this effect size shows that there is a small correlation between referential and sequential groups on coherence scores. The eta squared suggests that 0.1% of the variance in phase scores can be accounted for by the electrode placements.

Inferential statistic findings can be viewed on Table 20. Table 7 and Table 8 summarize the means and standard deviation of deviation scores for post-treatment referential and sequential placement. Table 15 and Table 16 summarize the means and standard deviation of *z-score*s for pre-treatment referential and sequential placement.

Percentage of Sites that Moved either Toward or Away from the Reference Database Mean

Each participant's electrode sites that were considered abnormal were totaled before treatment. These same site-pairs were evaluated for movement towards or away from the reference database mean after treatment using NeuroGuide 2.2.5 (Thatcher, 2005) software package. Percentages were calculated for each subject in the referential and sequential groups. Then all subjects' percentages of change were averaged.

Phase Z-score Change

Eighty-nine percent of all frontal site pairs that showed abnormal pre-treatment phase *z*-scores moved toward the reference database mean after 21-50 sessions of referential placement NF amplitude training, with 11% deviating away from the reference database mean following referential placement NF amplitude training. Eighty-four percent of all frontal site pairs that showed abnormal pre-treatment phase moved toward the reference database mean after

21-50 sessions of sequential placement NF amplitude training, with 16% deviating further from the reference database mean. Furthermore, all abnormal phase sites moved under 1 standard deviation. Findings can be viewed on Table 21. In addition, Figure 6 depicts the percentage of sites that moved towards or away from the reference database mean for both the sequential and referential placement groups.

Coherence Z-score Change

Only 64% of all frontal site pairs showing abnormal pre-treatment coherence moved toward the reference database mean after 21-50 sessions of sequential placement NF amplitude training. Thirty-six percent of all frontal site pairs with abnormal pre-treatment coherence moved away from the reference database mean following sequential placement NF amplitude training. However, 78% of all frontal site pairs showing abnormal pre-treatment coherence moved toward the reference database mean after 21-50 sessions of referential placement NF amplitude training. At the same time, 22% of all frontal site pairs with abnormal pre-treatment coherence deviated further from the reference database mean following NF amplitude training. Moreover, all abnormal phase sites moved under 1 standard deviation. Findings can be viewed on Table 22. Furthermore, Figure 7 depicts the percentage of sites that moved towards or away from the reference database mean for both the sequential and referential groups.

CHAPTER 4

DISCUSSION

This study looked at the differential effects of NF amplitude training using referential and sequential electrode placements on measures of phase and coherence. The goal was to clarify the clinical research question of whether sequential placement has significantly more effects on phase and coherence scores than referential placement. This question relates to the theoretical debate over whether amplitude training using one versus two active electrodes (both using a one channel amplifier) has different effects on measures of connectivity between cortical sites. In addition, the study looked at the percentage of abnormal phase and coherence *z*-scores. Any score above one standard deviation was defined as an abnormal *z*-score.

Referential Versus Sequential Placements

Hypothesis Testing Using Significance Test

The first and third hypotheses stated that, following NF training, there would be a difference between the referential and sequential placements on phase and coherence scores. Based on p-value significance tests, this study failed to reject the null hypotheses, $F(14, 1) = 0.449$, $p > .05$. The general linear model analysis showed that there was no significant difference between post-treatment referential and sequential electrode placement groups on phase and

coherence connectivity measures. However, when each individual frontal lobe site was analyzed, a statistical significance was found between post NF amplitude training referential and sequential placements on coherence scores at Fp1-F3 in the theta frequency, F (14, 1) = 17.3, p = 0.001. Furthermore, sequential electrode placements tend to have increased coherence (M = 0.62, SD = 0.64) compared to referential electrode placements (M = 0.28, SD = 0.48) at Fp1-F3 in the theta frequency. The magnitude of the difference between the two types of placements at Fp1-F3 was large (effect size r = 0.73). In addition, the eta square for the Fp1-F3 site shows that 55% of the variance in coherence scores could be accounted for by the type of electrode placement.

The significant p-value, large effect size, and large percentage of variance accounted for by electrode placements for the Fp1-F3 site suggest that differences may not be due to chance. In addition, the significant p-value was less than the Bonferroni adjustment, which further indicates that differences may not be due to unaccounted variables or relationships. This suggests that a change in connectivity occurred in the left hemisphere as a result of the electrode placement used. Moreover, the results show that sequential placement tends to increase coherence scores, while referential placement tends to decrease coherence scores (see Figure 4). This relationship is elaborated further in this paper.

Group differences could not be accounted for by p-value significance tests because this study's sample size was too small. Another reason for the statistical

insignificance could be due to the pre-treatment analysis phase and coherence deviation scores. That is, the pre-treatment NF training referential and sequential montage effect sizes were larger than post-treatment referential and sequential placement effect sizes. This indicates that large differences between referential and sequential placement groups existed before the treatment, and as NF amplitude training was introduced, differences decreased at the post-treatment comparison. This relationship is less apparent for the phase *z*-scores (see Figure 5 and Figure 6).

Emphasizing Effect Size and Eta Square

One limitation of the p-value is that it only answers dichotomous questions and ignores the degree of difference. For example, if a p-value for the chances of a disease in a population is near but less than (e.g. $p = 0.07$) the set alpha level (0.05) then the effect is dismissed. Researchers are required to conclude that a given disease does not exist in the population (Thompson, 1999). This conclusion limits the external validity of the results because researchers cannot decipher the degree to which the given disease exists. Vask, Gliner, and Morgan (2002) recommend the use of effect sizes to understand the practical significance of an effect in the real world rather than a dichotomous answer valid within a statistical realm. Another limitation of the p-value significance test is that it is dependent entirely on the sample size; as sample size increases, the possibility of having a significant p-value also increases. Therefore, an effect that has trivial

magnitude needs only a large sample size to produce a significant p-value. This tends to increase the chances of a Type I error (Kline, 2004; Krantz, 1999).

Authoritative sources on research statistics indicate that these two statistical procedures should be emphasized when conducting hypothesis testing and drawing conclusions about non-significant p-values (Cohen, 1994; Cohen, 1990; Prentice and Miller, 1992). Jacobe Cohen (1994), one of the most respected statisticians in the field of Psychology, has suggested that null hypothesis testing using criterion p- value significance tests has failed to support the progression of the research in the field. Cohen points out that in 1938 Joseph Berkson began to criticize null hypothesis testing using p-values, well before the field of Psychology took up this approach. However, because of the high utility of p-value significance testing within the Psychology field, this approach became common practice. Cohen has further pointed out that when researchers make decisions exclusively on p-value significance testing, or attempt null hypothesis testing based on a cut off score (e.g., $p < 0.05$), then they are limiting the possibilities of their results. Researchers should instead place more emphasis on other inferential statistics that summarize the magnitude of treatment effects such as eta (effect size *r*), Cohen's *d*, and eta squares, which elucidate the types of relationships that are possible within a given amount of data points (Cohen, 1994; Kline, 2004; Thompson, 1999).

Given that this study has a sample of 16 individuals, the best indicators to show true statistical difference between referential and sequential electrode

placements are effect sizes and eta squares (Cohen, 1994; Kline, 2004). The effect sizes allow examination of the magnitude of the difference between referential and sequential placement means while taking into account the small sample size. The eta squares, as mentioned earlier, describe the percentage of variance accounted for by electrode placement and connectivity measures.

Hypothesis Testing Using Effect Size and Eta Square

Although significance testing showed that only one site reached statistical significance, individual frontal lobe sites' effect sizes and eta squares were mostly in the medium to large range. This indicates that the difference between the referential and sequential electrode placements after NF amplitude training is moderately high, and there is a moderate to large relationship between referential and sequential placements on phase and coherence scores. In addition, a good proportion of the percentage of unknown variance in the data can be attributed to electrode placements. Therefore, true differences exist between both electrode placement groups on phase and coherence scores.

Results of this study provide support for the first and third hypotheses that following NF training, there would be a difference between the referential and sequential placements on phase and coherence scores. Consequently, the null hypothesis was rejected on the basis of the medium to large effect sizes and eta squares. NF amplitude training appears to have strong effects on phase and coherence measures at the frontal lobe sites analyzed in this sample of 16

clinical NF subjects, and NF amplitude training using sequential versus referential placements had differing effects on connectivity measures.

Percentage of Sites that Moved either Toward or Away from the Reference Database Mean

Phase Z-score Change

In this sample, most individuals' abnormal phase *z*-scores moved towards the reference database mean. This overall change toward the reference database mean effect was independent of electrode placement groups (e.g., referential or sequential). In other words, irrelevant of which electrode placement was used, both groups had a similar percentage of sites that moved toward the reference database mean. In the referential placement group, 89% of all frontal site pairs that showed abnormal pre-treatment phase *z*-scores were inclined toward the reference database mean after NF amplitude training, while 11% of all frontal site pairs with abnormal pre-treatment phase became more abnormal (or moved further from the reference database mean) following NF amplitude training. In the sequential placement group, 84% of all frontal site pairs that showed abnormal pre-treatment phase tended to move toward the reference database mean after NF amplitude training, whereas 16% of all frontal site pairs with abnormal pre-treatment phase became more abnormal following NF amplitude training.

Coherence Z-score Change

Similar to the phase *z*-scores, most individuals' abnormal coherence *z*-scores moved toward the reference database mean in both electrode placement groups. However, the referential placement group had a moderately higher percentage of sites that moved toward the reference database mean than the sequential placement group. In the referential placement group, 78% of all frontal site pairs showing abnormal pre-treatment coherence moved toward the reference database mean after NF amplitude training. Twenty-two percent of all frontal site pairs with abnormal pre-treatment coherence became more abnormal (or moved further from the reference database mean) following NF amplitude training. In the sequential placement database, only 64% of all frontal site pairs showing abnormal pre-treatment coherence moved toward the reference database mean after NF amplitude training. Thirty-six percent of all frontal site pairs with abnormal pre-treatment coherence moved further from the reference database mean following NF amplitude training.

The second and fourth hypothesis stated that at least 50% of the phase and coherence abnormalities would move toward the reference database mean following NF amplitude training. Both phase and coherence *z*-scores had higher than 50% of sites that moved toward the reference database mean. Therefore, the null hypothesis was rejected.

Results indicate that NF amplitude training, independent of electrode placement, tends to move abnormal phase and coherence scores towards the

reference database means (see Figure 7 and Figure 8). For example, both hypercoherence and hypocoherence *z*-scores that were greater than one standard deviation before NF amplitude training tended to move less than one standard deviation of the reference database mean after NF amplitude training. The same relationship was observed for abnormal phase *z*-scores as well.

The findings also suggest that, although both electrode placements tend to move connectivity *z*-scores closer to the reference database mean above the 50% expected rate, referential placements tend to have a slightly higher percentage of sites that moved toward the reference database mean when compared to sequential placements. This is less evident with the phase *z*-scores percentage; however, the coherence *z*-score percentage of sites that moved toward the reference database mean highlights the fundamental technical difference between the two placements. For example, the referential placements tend to move 89% of phase *z*-scores closer to the reference database mean, while sequential placements move 84% of phase *z*-scores closer to the reference database mean. However, referential placements tend to moved 78% of coherence *z*-scores closer to the reference database mean, while sequential placements moved toward the reference database mean only 64% of coherence *z*-scores.

Fehmi and Sundor (1989), quoted earlier in this paper stated that the debate over the use of referential versus sequential placements favors the referential recording method. When using sequential placements there is

difficulty in observing brain wave activity when the electrical potentials at two active electrodes fluctuate in phase and have equal amplitude with respect to an inactive point (ground). Due to common mode rejection, the Electroencephalograph (EEG) will show no fluctuation in voltage (Fehmi and Sundor, 1989). With referential placements the recordings are a measure of the absolute value of the brain waves; amplitude. This absolute value yields more accurate recording then relative electrical potential values such as sequential placements. Therefore, the difference between referential and sequential electrode placements on the abnormal sites percentage of change may reflect a measurement disadvantage in sequential placements.

Conclusion and Theoretical Implication

Lubar (1995) suggested that referential placements might yield different effects than sequential placements. Demos (2005) hypothesized that using referential placement NF training may change the activity under the site, while sequential placement NF training may increase the association between activity at two-electrode sites. If this logic holds, then one would expect to observe phase and coherence scores balancing out (i.e., decreased hypercoherence or increased hypocoherence scores) more often in the sequential placements group than in the referential placements group. Nonetheless, this research does not bear this out.

Overall, this study indicates that both referential and sequential electrode placement types tend to move connectivity scores toward the reference database mean. However, if both electrode placements tend to produce a similar percentage of change, then why are medium to large effect sizes found? Upon analyzing the results further, it became evident that a more specific and important factor is the direction in which sequential and referential placements shift coherence and phase scores within the frontal lobe.

This research demonstrates that using specific types of electrode placements to conduct NF training leads to specific directional changes on phase and coherence measures. The results suggest that referential placement NF training had a propensity to increase phase scores, while sequential placement NF training had a tendency to decreased phase scores (please see Figure 3). At the same time, referential placement NF training tended to decrease coherence scores, whereas sequential placement NF training had the tendency to increase coherence scores (see Figure 4).

Results of the analysis of inter-hemispheric (Fp1-Fp2, F3-F4, and F7-F8) phase *z*-score means showed that referential placement tended to decrease phase after NF amplitude training in the delta, theta, and alpha frequencies, but increased phase in the beta frequency. Sequential placement tended to decrease phase after NF amplitude training in the delta, theta, alpha, and beta frequencies (see Figure 9-12). Analysis of the inter-hemispheric coherence *z*-score means showed that referential placement tended to decrease connectivity after NF

amplitude training in the delta, theta, and beta frequencies, but increased connectivity in the alpha frequency. Sequential placement tended to decrease connectivity after NF amplitude training in the delta and beta frequencies, but increased connectivity in the theta and alpha frequencies (please see Figure 11). Right (Fp2-F4, F4-F8, and Fp2-F8) and left (Fp1-F3, F3-F7, and Fp1-F7) intra-hemispheric sites did not show a consistent pattern for phase and coherence scores.

Overall, this study provides evidence that suggests that frontal lobe EEG activity changes closer towards the reference database mean as a result of both types of electrode placements. These findings indicate that reorganization in brain function occurred as a result of NF amplitude training. This study further suggests that abnormal connectivity is balanced with NF amplitude training in directions specific to phase and coherence. A clinician's decision to use sequential or referential electrode placements can determine the direction of brain connectivity.

Goals for Future Research

Since the difference in post-treatment NF training phase and coherence measures produced by referential and sequential placements did not reach adjusted p-value significance, more research is needed to clarify the properties that govern the effects of amplitude training on neuronal-network connectivity and synchrony. This section will outline future theoretical direction for

researchers. In addition, suggestions are made regarding methodological improvements in the research design.

In this study, more than 70% of the subjects had NF amplitude training done in the frontal lobe regions. Researchers should make a significant effort to control for the location of the NF training site. That is, future research should compare referential and sequential placements groups who receive NF amplitude training in the same location (for example, only performing NF amplitude training at F3). By controlling for the NF training location, researchers could filter out other factors that may account for changes in connectivity.

All of the NF training done with subjects chosen for this study were single channel training. A related research question is whether two-channel amplitude training using referential and sequential placements changes connectivity measures in the same directions as one-channel amplitude training using referential and sequential placements. In the present study, most frontal sites, regardless of their degree of deviation from the reference database mean and despite the type of electrode placement, moved closer to the reference database mean using one-channel training. Therefore, researchers should also compare the rate of change in two-channel amplitude training versus one-channel amplitude training.

Furthermore, this study included only 16 subjects. A larger sample could provide a larger power and highlight true phase and coherence changes while taking into account Type I and Type II error. In addition, due to the nature of

archival data, a control group was not available for this study. Future research should focus on multivariate repeated measures designs in which pre- and post-treatment control groups are compared with pre- and post- treatment groups. Repeated measures design could account for individual differences at pre-treatment comparison. Individual difference was not a factor that was considered in this study's general linear model analysis. In regard to abnormal *z*-scores, a regression toward the mean would be expected (i.e., it would be expected that very large abnormal *z*-scores would move toward the reference database mean).

This study used z-scores based on a reference database provided in NeuroGuide 2.2.5. Johnson and Gunkelman (2003) point out that most quantitative-electroencephalograph (QEEG) databases do not meet criteria for normative sample, and there is a high variable (e.g. 0-60Hz, number of electrodes) to case ratio, which increases false positive results. Therefore, the use of QEEG database z-scores may be controversial. The use of a control group would eliminate the need for a database, and would also correct for expected regression toward the mean.

Another variant in this study was the incorporation of psychotherapy as an adjunctive treatment to NF. Although it is recommended that all biofeedback treatment be integrated with psychotherapy/counseling (Demos, 2005), statistical analyses do not separate out the effects of the two treatments. This presents many problems for researchers because psychotherapy/counseling treatments may contaminate statistical findings. Moreover, this confounding variable could

dramatically increase Type I error. Consequently, it is suggested that researchers analyze psychotherapy/counseling and NF as separate groups.

The final suggestion for future research is related to the technical concept of wave amplitude and connectivity. Although the definition of coherence states that the recording of a wave is independent of amplitude (Senf, 1998), this study demonstrates that manipulation of the amplitude of a wave, through either referential or sequential electrode placements, can influence the phase and coherence between two waves. This study points out that by simply changing the height of a brain wave the morphology and synchrony of two frequencies can fluctuate accordingly. In other words, manipulation of the height or strength of waves through feedback loops or NF can increase or decrease the phase lock relationship or communication between cortical sites. This relationship needs further investigation given the current definition of coherence.

Table 1

Descriptive Statistics for Pre-treatment Referential Placement Phase Deviation Scores

Site	Mean	Std. Deviation	Site	Mean	Std. Deviation
FP1_FP2D	0.0635	0.0504	FP1_FP2A	0.3264	0.2182
FP1_F3D	0.0692	0.0262	FP1_F3A	0.4009	0.3632
FP1_F7D	0.1050	0.0709	FP1_F7A	1.1329	0.5490
FP2_F4D	0.1160	0.0670	FP2_F4A	0.3033	0.1674
FP2_F8D	0.2555	0.1523	FP2_F8A	0.4559	0.2713
F3_F4D	0.1813	0.1379	F3_F4A	0.4655	0.3408
F3_F7D	0.4313	0.2950	F3_F7A	0.6615	0.4652
F4_F8D	0.2240	0.1641	F4_F8A	0.3883	0.2638
F7_F8D	0.3653	0.2459	F7_F8A	0.3160	0.3015
FP1_FP2T	0.3331	0.1516	FP1_FP2B	0.3735	0.1960
FP1_F3T	0.2490	0.1205	FP1_F3B	0.0588	0.0618
FP1_F7T	0.2381	0.1786	FP1_F7B	0.1835	0.1156
FP2_F4T	0.2759	0.1719	FP2_F4B	0.1530	0.1248
FP2_F8T	0.5077	0.2859	FP2_F8B	0.5173	0.4116
F3_F4T	0.3044	0.0965	F3_F4B	0.2216	0.0699
F3_F7T	0.6453	0.4813	F3_F7B	0.2099	0.0917
F4_F8T	0.5719	0.3138	F4_F8B	0.3211	0.2858
F7_F8T	0.5100	0.5131	F7_F8B	0.3183	0.1481
			Total Mean Pre-treatment Phase	0.3404	0.2213

Table 2

Descriptive Statistics for Pre-treatment Sequential Placement Phase Deviation Scores

Site	Mean	Std. Deviation	Site	Mean	Std. Deviation
FP1_FP2D	0.0805	0.0341	FP1_FP2A	0.5728	0.1836
FP1_F3D	0.0977	0.0391	FP1_F3A	1.3415	1.7752
FP1_F7D	0.1116	0.1105	FP1_F7A	1.4668	1.4210
FP2_F4D	0.2155	0.1533	FP2_F4A	0.5171	0.4283
FP2_F8D	0.2658	0.2252	FP2_F8A	0.7833	0.5970
F3_F4D	0.2952	0.2128	F3_F4A	0.6925	0.5827
F3_F7D	0.6812	0.3232	F3_F7A	1.1093	1.0823
F4_F8D	0.2638	0.1476	F4_F8A	0.4358	0.4181
F7_F8D	0.6075	0.3969	F7_F8A	0.3766	0.3190
FP1_FP2T	0.4035	0.2340	FP1_FP2B	1.0189	0.7142
FP1_F3T	0.3740	0.4976	FP1_F3B	0.4630	0.4604
FP1_F7T	0.3053	0.2640	FP1_F7B	0.6593	0.5777
FP2_F4T	0.4365	0.3643	FP2_F4B	0.4495	0.6838
FP2_F8T	0.7456	0.3585	FP2_F8B	1.3341	1.7419
F3_F4T	0.3780	0.3259	F3_F4B	1.0362	1.1967
F3_F7T	0.7961	1.1613	F3_F7B	0.2894	0.2472
F4_F8T	0.4564	0.2188	F4_F8B	0.5615	0.7849
F7_F8T	0.4670	0.4247	F7_F8B	0.6028	0.4448
			Total Mean Pre-treatment Phase	0.5748	0.5320

Table 3

Descriptive Statistics for Post-treatment Referential Placement Phase Deviation Scores

Site	Mean	Std. Deviation	Site	Mean	Std. Deviation
FP1_FP2D	0.0790	0.0719	FP1_FP2A	0.4274	0.3220
FP1_F3D	0.0851	0.0727	FP1_F3A	0.5561	0.4376
FP1_F7D	0.1549	0.0670	FP1_F7A	1.2970	1.0867
FP2_F4D	0.2219	0.1145	FP2_F4A	0.4730	0.2817
FP2_F8D	0.3095	0.1896	FP2_F8A	0.3650	0.2532
F3_F4D	0.2603	0.1385	F3_F4A	0.7515	0.4160
F3_F7D	0.4724	0.3667	F3_F7A	0.8018	0.6879
F4_F8D	0.2885	0.2124	F4_F8A	0.2855	0.2428
F7_F8D	0.5751	0.4160	F7_F8A	0.3272	0.1867
FP1_FP2T	0.2644	0.1317	FP1_FP2B	0.4470	0.7566
FP1_F3T	0.1601	0.1642	FP1_F3B	0.4821	0.7329
FP1_F7T	0.3304	0.2805	FP1_F7B	0.2675	0.3965
FP2_F4T	0.2595	0.2039	FP2_F4B	0.3730	0.3027
FP2_F8T	0.3964	0.2725	FP2_F8B	0.4753	0.4900
F3_F4T	0.1825	0.1466	F3_F4B	0.5274	0.7738
F3_F7T	0.8848	0.7643	F3_F7B	0.2601	0.3006
F4_F8T	0.2849	0.2671	F4_F8B	0.5110	0.2989
F7_F8T	0.7174	0.5948	F7_F8B	0.1938	0.1429
			Total Mean Pos Phase	0.4097	0.3496

Table 4

Descriptive Statistics for Post-treatment Sequential Placement Phase Deviation Scores

Site	Mean	Std. Deviation	Site	Mean	Std. Deviation
FP1_FP2D	0.0700	0.0343	FP1_FP2A	0.2584	0.2749
FP1_F3D	0.0969	0.0754	FP1_F3A	0.8099	0.7352
FP1_F7D	0.0938	0.0852	FP1_F7A	1.2735	1.7968
FP2_F4D	0.2715	0.2208	FP2_F4A	0.5339	0.3333
FP2_F8D	0.4177	0.4428	FP2_F8A	0.5518	0.5176
F3_F4D	0.3463	0.2970	F3_F4A	0.4409	0.2866
F3_F7D	0.3331	0.2648	F3_F7A	0.7513	0.3349
F4_F8D	0.3318	0.3235	F4_F8A	0.5296	0.5328
F7_F8D	0.4948	0.2922	F7_F8A	0.2971	0.3068
FP1_FP2T	0.3429	0.1701	FP1_FP2B	0.6428	0.5969
FP1_F3T	0.2695	0.1686	FP1_F3B	0.2744	0.2038
FP1_F7T	0.2885	0.1351	FP1_F7B	0.6757	0.5503
FP2_F4T	0.5249	0.2901	FP2_F4B	0.6867	0.8683
FP2_F8T	0.5506	0.6837	FP2_F8B	0.3387	0.2467
F3_F4T	0.3173	0.3511	F3_F4B	0.9408	0.9919
F3_F7T	0.5259	0.4478	F3_F7B	0.2590	0.3835
F4_F8T	0.5608	0.1985	F4_F8B	0.6755	0.7292
F7_F8T	0.7236	0.5303	F7_F8B	0.2331	0.2048
			Total Mean Pos-treatment Phase	0.4648	0.4140

Table 5

Descriptive Statistics for Pre-treatment Referential Placement Coherence Deviation Scores

Site	Mean	Std. Deviation	Site	Mean	Std. Deviation
FP1_FP2D	0.2548	0.0835	FP1_FP2A	0.4633	0.2509
FP1_F3D	0.4609	0.2116	FP1_F3A	1.1676	0.5974
FP1_F7D	0.4463	0.2241	FP1_F7A	0.7706	0.5174
FP2_F4D	0.5596	0.2604	FP2_F4A	0.7900	0.3152
FP2_F8D	0.3340	0.1757	FP2_F8A	0.5601	0.4154
F3_F4D	0.4398	0.2040	F3_F4A	0.4988	0.3817
F3_F7D	0.3547	0.2480	F3_F7A	1.0015	0.6233
F4_F8D	0.4047	0.2919	F4_F8A	0.9530	0.5956
F7_F8D	0.6953	0.4650	F7_F8A	0.6249	0.4897
FP1_FP2T	0.3437	0.1759	FP1_FP2B	0.8995	0.6757
FP1_F3T	0.4632	0.3261	FP1_F3B	0.8274	0.5297
FP1_F7T	0.4462	0.2970	FP1_F7B	0.8004	0.4581
FP2_F4T	0.4989	0.2144	FP2_F4B	1.0989	1.0693
FP2_F8T	0.2048	0.1190	FP2_F8B	0.6354	0.7377
F3_F4T	0.6176	0.2679	F3_F4B	0.5320	0.3600
F3_F7T	0.5347	0.4624	F3_F7B	0.5546	0.3145
F4_F8T	0.5056	0.2705	F4_F8B	1.2925	1.6353
F7_F8T	0.7765	0.6539	F7_F8B	0.3217	0.3589
			Mean Pre-treatment Coherence	0.6148	0.4244

Table 6

Descriptive Statistics for Pre-treatment Sequential Placement Coherence Deviation Scores

Site	Mean	Std. Deviation	Site	Mean	Std. Deviation
FP1_FP2D	0.5038	0.3694	FP1_FP2A	0.4342	0.5019
FP1_F3D	0.7893	0.4709	FP1_F3A	2.3621	2.6607
FP1_F7D	0.7425	0.4954	FP1_F7A	0.9295	0.9370
FP2_F4D	0.6950	0.3378	FP2_F4A	1.3050	0.8471
FP2_F8D	0.4221	0.3400	FP2_F8A	0.5474	0.6873
F3_F4D	0.7578	0.3047	F3_F4A	0.7234	0.9714
F3_F7D	0.6504	0.4468	F3_F7A	1.7906	3.0627
F4_F8D	0.8823	0.5819	F4_F8A	0.6665	0.8130
F7_F8D	1.1104	1.0465	F7_F8A	0.4526	0.2832
FP1_FP2T	0.5694	0.3762	FP1_FP2B	0.7683	0.5476
FP1_F3T	0.9640	0.7118	FP1_F3B	0.7913	0.7029
FP1_F7T	0.3974	0.2401	FP1_F7B	0.5731	0.4545
FP2_F4T	0.4313	0.1805	FP2_F4B	1.0788	0.6747
FP2_F8T	0.2350	0.1025	FP2_F8B	0.3943	0.3147
F3_F4T	0.9406	0.5327	F3_F4B	0.9256	0.8106
F3_F7T	1.0981	1.2725	F3_F7B	0.5484	0.5459
F4_F8T	0.6399	0.3782	F4_F8B	1.3105	1.6331
F7_F8T	1.0027	1.0122	F7_F8B	0.4165	0.2729
			Total Mean Pre-treatment Coherence	0.8014	0.7200

Table 7

Descriptive Statistics for Post-treatment Referential Placement Coherence Deviation Scores

Site	Mean	Std. Deviation	Site	Mean	Std. Deviation
FP1_FP2D	0.2174	0.0784	FP1_FP2A	0.5896	0.4761
FP1_F3D	0.4644	0.2150	FP1_F3A	0.9397	0.4832
FP1_F7D	0.5971	0.4403	FP1_F7A	0.7291	0.4031
FP2_F4D	0.4699	0.2551	FP2_F4A	0.8248	0.4905
FP2_F8D	0.2436	0.2143	FP2_F8A	0.5538	0.3388
F3_F4D	0.6839	0.3497	F3_F4A	0.6900	0.2885
F3_F7D	0.4760	0.3555	F3_F7A	0.7805	0.3856
F4_F8D	0.3369	0.3282	F4_F8A	0.9648	0.4763
F7_F8D	0.7768	0.4082	F7_F8A	0.4660	0.3693
FP1_FP2T	0.4303	0.2187	FP1_FP2B	1.0983	0.5711
FP1_F3T	0.2941	0.1683	FP1_F3B	0.8989	0.6176
FP1_F7T	0.6975	0.5969	FP1_F7B	0.7911	0.4835
FP2_F4T	0.2939	0.1662	FP2_F4B	1.3225	1.1790
FP2_F8T	0.3108	0.2121	FP2_F8B	0.7582	0.4925
F3_F4T	0.7472	0.4007	F3_F4B	0.6954	0.4792
F3_F7T	0.6351	0.5724	F3_F7B	0.4641	0.3052
F4_F8T	0.3710	0.3059	F4_F8B	1.4612	0.8412
F7_F8T	1.0979	0.8717	F7_F8B	0.2869	0.2224
			Total Mean Post-treatment Coherence	0.6516	0.4184

Table 8

Descriptive Statistics for Post-treatment Sequential Placement Coherence Deviation Scores

Site	Mean	Std. Deviation	Site	Mean	Std. Deviation
FP1_FP2D	0.4748	0.4149	FP1_FP2A	0.5131	0.4827
FP1_F3D	0.5025	0.4852	FP1_F3A	1.3068	1.1003
FP1_F7D	0.7536	0.5244	FP1_F7A	0.7559	0.5972
FP2_F4D	0.5389	0.4108	FP2_F4A	0.9110	0.6560
FP2_F8D	0.4321	0.4063	FP2_F8A	0.6650	0.3264
F3_F4D	0.7445	0.5478	F3_F4A	0.6251	0.6628
F3_F7D	0.8546	0.5189	F3_F7A	0.7920	1.0352
F4_F8D	0.6551	0.5199	F4_F8A	1.1157	1.1429
F7_F8D	1.2670	0.7914	F7_F8A	0.5207	0.5528
FP1_FP2T	0.6438	0.3442	FP1_FP2B	0.7731	0.5975
FP1_F3T	0.6981	0.2172	FP1_F3B	0.7514	0.4249
FP1_F7T	0.5483	0.3374	FP1_F7B	0.7414	0.6680
FP2_F4T	0.5042	0.2823	FP2_F4B	1.2794	0.9478
FP2_F8T	0.2933	0.2067	FP2_F8B	0.7954	0.3315
F3_F4T	0.7134	0.5611	F3_F4B	0.5963	0.6386
F3_F7T	0.9276	0.5576	F3_F7B	0.6303	0.5330
F4_F8T	0.6039	0.2423	F4_F8B	1.7831	1.1696
F7_F8T	1.1218	0.8007	F7_F8B	0.2987	0.0973
			Total Mean Post-treatment Coherence	0.7537	0.5593

Table 9

Descriptive Statistics for Pre-treatment Referential Placement Phase Z-scores

Site	Mean	Std. Deviation	Site	Mean	Std. Deviation
FP1_FP2D	0.5566	0.0504	FP1_FP2A	0.3100	0.3518
FP1_F3D	0.5628	0.0262	FP1_F3A	-0.1033	0.4258
FP1_F7D	0.6319	0.1216	FP1_F7A	-0.5649	1.3193
FP2_F4D	-0.1693	0.1354	FP2_F4A	-0.7360	0.3646
FP2_F8D	0.1980	0.3127	FP2_F8A	-0.4821	0.4343
F3_F4D	-0.0591	0.2319	F3_F4A	-0.3966	0.5864
F3_F7D	0.4314	0.5444	F3_F7A	0.0221	0.8233
F4_F8D	0.7310	0.2720	F4_F8A	0.3013	0.4335
F7_F8D	0.0293	0.4528	F7_F8A	0.0128	0.4518
FP1_FP2T	0.3403	0.1516	FP1_FP2B	0.2768	0.2699
FP1_F3T	0.4283	0.2394	FP1_F3B	-0.2795	0.0852
FP1_F7T	0.5484	0.2993	FP1_F7B	-0.5471	0.1531
FP2_F4T	-0.3386	0.3342	FP2_F4B	-0.7933	0.1331
FP2_F8T	-0.0979	0.6112	FP2_F8B	0.0520	0.4413
F3_F4T	-0.5720	0.2571	F3_F4B	-0.5549	0.2437
F3_F7T	-0.0070	0.8091	F3_F7B	0.2073	0.2183
F4_F8T	0.4036	0.6839	F4_F8B	0.8361	0.2888
F7_F8T	-0.1048	0.6526	F7_F8B	0.6493	0.3124
			Total Mean Pre-treatment Phase	0.0479	0.3756

Table 10

Descriptive Statistics for Pre-treatment Sequential Placement Phase Z-scores

Site	Mean	Std. Deviation	Site	Mean	Std. Deviation
FP1_FP2D	0.6838	0.0641	FP1_FP2A	0.7113	0.6032
FP1_F3D	0.7013	0.0822	FP1_F3A	0.5813	2.2538
FP1_F7D	0.7313	0.1537	FP1_F7A	-0.8763	2.1094
FP2_F4D	-0.0963	0.2749	FP2_F4A	-0.7125	0.6976
FP2_F8D	0.2050	0.3605	FP2_F8A	-1.1363	0.9671
F3_F4D	0.0413	0.3785	F3_F4A	-0.1325	0.9303
F3_F7D	0.3263	0.7950	F3_F7A	-0.3450	1.5935
F4_F8D	0.5425	0.3017	F4_F8A	-0.1350	0.5828
F7_F8D	0.1950	0.7561	F7_F8A	-0.0450	0.5119
FP1_FP2T	1.0088	0.3388	FP1_FP2B	0.9388	1.2529
FP1_F3T	0.7425	0.6155	FP1_F3B	-0.3238	0.6753
FP1_F7T	0.3913	0.4093	FP1_F7B	-0.2325	0.8974
FP2_F4T	-0.2088	0.5892	FP2_F4B	-0.5000	0.8233
FP2_F8T	-0.1963	0.8722	FP2_F8B	-0.9388	2.1911
F3_F4T	-0.1563	0.4723	F3_F4B	-0.4788	1.6291
F3_F7T	-0.4388	1.4225	F3_F7B	0.4038	0.3828
F4_F8T	0.2763	0.5306	F4_F8B	0.2000	0.9271
F7_F8T	0.5825	0.5431	F7_F8B	0.2750	0.7571
			Total Mean Pre-treatment Phase	0.0718	0.7985

Table 11

Descriptive Statistics for Post-treatment Referential Placement Phase Z-scores

Site	Mean	Std. Deviation	Site	Mean	Std. Deviation
FP1_FP2D	0.5688	0.1080	FP1_FP2A	0.3675	0.5541
FP1_F3D	0.6350	0.1143	FP1_F3A	0.0363	0.7283
FP1_F7D	0.7263	0.1773	FP1_F7A	-0.2688	1.7094
FP2_F4D	-0.1988	0.2557	FP2_F4A	-0.4088	0.5694
FP2_F8D	0.0813	0.3764	FP2_F8A	-0.3163	0.4377
F3_F4D	-0.1975	0.2924	F3_F4A	-0.3538	0.9038
F3_F7D	0.3025	0.6206	F3_F7A	0.2388	1.0988
F4_F8D	0.5063	0.3718	F4_F8A	0.3025	0.3902
F7_F8D	-0.0588	0.7355	F7_F8A	-0.0075	0.3858
FP1_FP2T	0.5838	0.3115	FP1_FP2B	0.6938	0.8472
FP1_F3T	0.6488	0.2272	FP1_F3B	-0.4888	0.8912
FP1_F7T	0.6000	0.4463	FP1_F7B	-0.3175	0.4458
FP2_F4T	-0.0713	0.3328	FP2_F4B	-0.5388	0.3030
FP2_F8T	-0.0988	0.4900	FP2_F8B	0.3325	0.7055
F3_F4T	-0.2863	0.2359	F3_F4B	-0.2488	0.9475
F3_F7T	-0.5225	1.1885	F3_F7B	0.3163	0.3986
F4_F8T	0.2200	0.4059	F4_F8B	0.8675	0.5664
F7_F8T	-0.0550	0.9662	F7_F8B	0.5188	0.2513
			Total Mean Post-treatment Phase	0.1141	0.5497

Table 12

Descriptive Statistics for Post-treatment Sequential Placement Phase Z-scores

Site	Mean	Std. Deviation	Site	Mean	Std. Deviation
FP1_FP2D	0.6138	0.0796	FP1_FP2A	0.2138	0.3798
FP1_F3D	0.6600	0.1256	FP1_F3A	-0.2100	1.1276
FP1_F7D	0.6800	0.1282	FP1_F7A	-1.0563	2.2169
FP2_F4D	-0.0650	0.3580	FP2_F4A	-0.6038	0.6527
FP2_F8D	0.2088	0.6268	FP2_F8A	-0.6200	0.7676
F3_F4D	-0.0025	0.4617	F3_F4A	-0.3688	0.5516
F3_F7D	0.1775	0.4385	F3_F7A	0.0975	0.8654
F4_F8D	0.5988	0.4787	F4_F8A	0.2325	0.7757
F7_F8D	0.1425	0.5943	F7_F8A	0.1750	0.4321
FP1_FP2T	0.5588	0.4042	FP1_FP2B	0.1450	0.8642
FP1_F3T	0.5125	0.3260	FP1_F3B	-0.3313	0.3468
FP1_F7T	0.4750	0.3297	FP1_F7B	-0.6875	0.8867
FP2_F4T	-0.2450	0.6244	FP2_F4B	-1.2850	1.0629
FP2_F8T	-0.3400	0.8935	FP2_F8B	0.3163	0.4366
F3_F4T	-0.3975	0.4841	F3_F4B	-0.5175	1.4037
F3_F7T	-0.0275	0.6684	F3_F7B	0.1500	0.4639
F4_F8T	0.2488	0.6315	F4_F8B	1.3463	0.9928
F7_F8T	0.1188	0.9334	F7_F8B	0.5113	0.3210
			Total Mean Post-treatment Phase	0.0396	0.6426

Table 13

Descriptive Statistics for Pre-treatment Referential Placement Coherence Z-scores

Site	Mean	Std. Deviation	Site	Mean	Std. Deviation
FP1_FP2D	1.5435	0.1843	FP1_FP2A	0.5226	0.5552
FP1_F3D	1.4979	0.5010	FP1_F3A	-0.0799	1.0528
FP1_F7D	2.0373	0.4201	FP1_F7A	-0.3468	0.8583
FP2_F4D	1.2411	0.6396	FP2_F4A	-0.1711	0.8033
FP2_F8D	1.2638	0.3636	FP2_F8A	-0.2276	0.7271
F3_F4D	2.1866	0.4721	F3_F4A	0.4463	0.6191
F3_F7D	1.6403	0.3888	F3_F7A	0.0955	0.9922
F4_F8D	1.6888	0.4373	F4_F8A	0.2244	1.1801
F7_F8D	2.0866	0.7677	F7_F8A	-0.0569	0.8201
FP1_FP2T	1.5795	0.3770	FP1_FP2B	0.4714	1.1661
FP1_F3T	0.4554	0.5273	FP1_F3B	0.4401	1.0306
FP1_F7T	0.6763	0.4853	FP1_F7B	0.3261	0.9700
FP2_F4T	0.1673	0.5723	FP2_F4B	0.3055	1.5761
FP2_F8T	0.5171	0.2488	FP2_F8B	0.0631	1.0003
F3_F4T	1.4358	0.6927	F3_F4B	0.3363	0.6333
F3_F7T	1.0813	0.6091	F3_F7B	0.3269	0.6709
F4_F8T	1.0425	0.5895	F4_F8B	-0.2244	2.1405
F7_F8T	1.3925	1.0464	F7_F8B	-0.1645	0.4915
			Total Mean Pre-treatment Coherence	0.7172	0.7392

Table 14

Descriptive Statistics for Pre-treatment Sequential Placement Coherence Z-scores

Site	Mean	Std. Deviation	Site	Mean	Std. Deviation
FP1_FP2D	1.1375	0.6163	FP1_FP2A	0.5225	0.6844
FP1_F3D	1.1388	0.9488	FP1_F3A	-1.7588	3.5569
FP1_F7D	1.4425	0.8796	FP1_F7A	-1.2038	1.2870
FP2_F4D	1.0000	0.8054	FP2_F4A	-0.9375	1.5799
FP2_F8D	0.9613	0.5424	FP2_F8A	-0.3200	0.9016
F3_F4D	1.8150	0.8429	F3_F4A	0.0425	1.2233
F3_F7D	1.2063	0.7939	F3_F7A	-1.2913	3.5336
F4_F8D	1.1563	1.0710	F4_F8A	0.2013	1.0816
F7_F8D	1.2938	1.5243	F7_F8A	-0.2750	0.5500
FP1_FP2T	1.2925	0.7005	FP1_FP2B	0.7463	0.9734
FP1_F3T	-0.0525	1.2221	FP1_F3B	0.4938	1.1009
FP1_F7T	0.1450	0.3974	FP1_F7B	0.2638	0.7624
FP2_F4T	0.0663	0.4940	FP2_F4B	-0.0650	1.3221
FP2_F8T	0.4913	0.2705	FP2_F8B	0.1950	0.5231
F3_F4T	1.1225	1.1254	F3_F4B	-0.0900	1.2600
F3_F7T	0.3125	1.6808	F3_F7B	0.3638	0.8001
F4_F8T	0.7913	0.7702	F4_F8B	-0.1450	2.1522
F7_F8T	1.1175	1.4677	F7_F8B	-0.3038	0.5155
			Total Mean Pre-treatment Coherence	0.3577	1.1100

Table 15

Descriptive Statistics for Post-treatment Referential Placement Coherence Z-scores

Site	Mean	Std. Deviation	Site	Mean	Std. Deviation
FP1_FP2D	1.4538	0.2399	FP1_FP2A	0.4475	0.7518
FP1_F3D	1.2350	0.5212	FP1_F3A	0.0013	1.0417
FP1_F7D	1.5163	0.7377	FP1_F7A	-0.1200	1.0398
FP2_F4D	0.9688	0.5486	FP2_F4A	-0.1575	0.9382
FP2_F8D	1.1425	0.3396	FP2_F8A	0.1538	0.6708
F3_F4D	1.8075	0.8270	F3_F4A	0.4150	0.6871
F3_F7D	1.3013	0.6765	F3_F7A	0.1538	0.8527
F4_F8D	1.5725	0.4830	F4_F8A	0.1700	1.0894
F7_F8D	1.5925	0.9380	F7_F8A	0.1275	0.5967
FP1_FP2T	1.3513	0.5403	FP1_FP2B	0.4138	1.2147
FP1_F3T	0.2750	0.4766	FP1_F3B	0.3425	1.1064
FP1_F7T	0.1900	0.9720	FP1_F7B	0.5388	1.1825
FP2_F4T	0.0525	0.4367	FP2_F4B	0.1863	1.7610
FP2_F8T	0.5413	0.3939	FP2_F8B	-0.0350	0.9753
F3_F4T	0.9625	0.7897	F3_F4B	0.1363	0.8057
F3_F7T	0.7638	0.9370	F3_F7B	0.3300	0.6133
F4_F8T	0.9313	0.4861	F4_F8B	-0.3838	1.6995
F7_F8T	0.6813	1.4713	F7_F8B	-0.0800	0.3951
			Total Mean Post-treatment Coherence	0.5827	0.8121

Table 16

Descriptive Statistics for Post-treatment Sequential Placement Coherence Z-scores

Site	Mean	Std. Deviation	Site	Mean	Std. Deviation
FP1_FP2D	1.3250	0.4025	FP1_FP2A	0.4725	0.7851
FP1_F3D	1.2688	0.6626	FP1_F3A	-0.3638	1.8385
FP1_F7D	1.9275	0.9368	FP1_F7A	-0.1925	0.8397
FP2_F4D	1.0188	0.7175	FP2_F4A	-0.3913	1.2735
FP2_F8D	1.1188	0.4978	FP2_F8A	-0.0163	0.8705
F3_F4D	1.8400	0.8127	F3_F4A	0.2388	1.0192
F3_F7D	1.3488	0.9731	F3_F7A	-0.1888	1.3790
F4_F8D	1.3213	0.7210	F4_F8A	-0.0025	1.7234
F7_F8D	1.5675	1.7196	F7_F8A	-0.0763	0.8307
FP1_FP2T	1.2263	0.6071	FP1_FP2B	0.3113	1.1365
FP1_F3T	0.6163	0.6413	FP1_F3B	0.4275	0.9458
FP1_F7T	0.7363	0.7434	FP1_F7B	0.1700	0.7421
FP2_F4T	0.3000	0.5164	FP2_F4B	-0.2088	1.7265
FP2_F8T	0.6538	0.2876	FP2_F8B	0.1488	0.8729
F3_F4T	1.1025	1.0965	F3_F4B	-0.0250	1.0156
F3_F7T	0.7638	1.1008	F3_F7B	0.1088	0.8677
F4_F8T	0.7825	0.6742	F4_F8B	-0.7688	2.3453
F7_F8T	1.0588	1.8406	F7_F8B	-0.2088	0.4509
			Total Mean Post-treatment Coherence	0.5392	0.9893

Table 17

General Linear Model: Analysis of Variance on Pre-treatment Referential and Sequential Phase Deviation Scores

Dependent Variable	Type III Sum of Squares	*df*	Error *df*	Mean Square	*F*	Sig. (Bonf. alpha = .001)	Effect Size *r*	Partial Eta Squared
FP1_FP2D	0.00116	1	14	0.0012	0.6267	0.4418	0.207	0.0428
FP1_F3D	0.003245	1	14	0.0032	2.9315	0.1089	0.416	0.1731
FP1_F7D	0.000172	1	14	0.0002	0.0200	0.8896	0.038	0.0014
FP2_F4D	0.039601	1	14	0.0396	2.8297	0.1147	0.410	0.1681
FP2_F8D	0.000424	1	14	0.0004	0.0115	0.9162	0.029	0.0008
F3_F4D	0.05187	1	14	0.0519	1.6135	0.2247	0.321	0.1033
F3_F7D	0.24975	1	14	0.2498	2.6086	0.1286	0.396	0.1571
F4_F8D	0.00634	1	14	0.0063	0.2603	0.6178	0.135	0.0183
F7_F8D	0.234771	1	14	0.2348	2.1537	0.1643	0.365	0.1333
FP1_FP2T	0.019793	1	14	0.0198	0.5091	0.4873	0.187	0.0351
FP1_F3T	0.0625	1	14	0.0625	0.4769	0.5011	0.181	0.0329
FP1_F7T	0.01804	1	14	0.0180	0.3553	0.5607	0.157	0.0247
FP2_F4T	0.103161	1	14	0.1032	1.2714	0.2785	0.289	0.0833
FP2_F8T	0.226338	1	14	0.2263	2.1533	0.1644	0.365	0.1333
F3_F4T	0.021646	1	14	0.0216	0.3747	0.5503	0.161	0.0261
F3_F7T	0.091053	1	14	0.0911	0.1152	0.7393	0.090	0.0082
F4_F8T	0.053361	1	14	0.0534	0.7293	0.4075	0.223	0.0495
F7_F8T	0.007412	1	14	0.0074	0.0334	0.8576	0.049	0.0024
FP1_FP2A	0.242803	1	14	0.2428	5.9728	0.0284	0.547	0.2990
FP1_F3A	3.539102	1	14	3.5391	2.1560	0.1641	0.365	0.1334
FP1_F7A	0.44589	1	14	0.4459	0.3843	0.5453	0.163	0.0267
FP2_F4A	0.182943	1	14	0.1829	1.7304	0.2095	0.332	0.1100
FP2_F8A	0.428616	1	14	0.4286	1.9936	0.1798	0.353	0.1247
F3_F4A	0.206173	1	14	0.2062	0.9048	0.3576	0.246	0.0607
F3_F7A	0.802032	1	14	0.8020	1.1559	0.3005	0.276	0.0763
F4_F8A	0.009025	1	14	0.0090	0.0739	0.7898	0.072	0.0052
F7_F8A	0.014656	1	14	0.0147	0.1521	0.7024	0.104	0.0107
FP1_FP2B	1.666197	1	14	1.6662	6.0762	0.0272	0.550	0.3027
FP1_F3B	0.653622	1	14	0.6536	6.0583	0.0274	0.550	0.3020
FP1_F7B	0.905174	1	14	0.9052	5.2158	0.0385	0.521	0.2714
FP2_F4B	0.35176	1	14	0.3518	1.4561	0.2475	0.307	0.0942
FP2_F8B	2.668731	1	14	2.6687	1.6661	0.2177	0.326	0.1064
F3_F4B	2.653845	1	14	2.6538	3.6936	0.0752	0.457	0.2088
F3_F7B	0.025291	1	14	0.0253	0.7273	0.4081	0.222	0.0494
F4_F8B	0.231241	1	14	0.2312	0.6628	0.4292	0.213	0.0452
F7_F8B	0.323761	1	14	0.3238	2.9464	0.1081	0.417	0.1739

Table 18

General Linear Model: Analysis of Variance on Pre-treatment Referential and Sequential Coherence Deviation Scores

Dependent Variable	Type III Sum of Squares	*df*	Error *df*	Mean Square	*F*	Sig. (Bonf. alpha = .001)	Effect Size *r*	Partial Eta Squared
FP1_FP2D	0.24788	1	14	0.2479	3.4573	0.0841	0.445	0.1980
FP1_F3D	0.431444	1	14	0.4314	3.2382	0.0935	0.433	0.1879
FP1_F7D	0.350945	1	14	0.3509	2.3745	0.1456	0.381	0.1450
FP2_F4D	0.073306	1	14	0.0733	0.8059	0.3845	0.233	0.0544
FP2_F8D	0.031086	1	14	0.0311	0.4245	0.5252	0.172	0.0294
F3_F4D	0.404297	1	14	0.4043	6.0141	0.0279	0.548	0.3005
F3_F7D	0.349798	1	14	0.3498	2.6796	0.1239	0.401	0.1607
F4_F8D	0.912503	1	14	0.9125	4.3057	0.0569	0.485	0.2352
F7_F8D	0.689211	1	14	0.6892	1.0512	0.3226	0.264	0.0698
FP1_FP2T	0.20388	1	14	0.2039	2.3646	0.1464	0.380	0.1445
FP1_F3T	1.003378	1	14	1.0034	3.2736	0.0919	0.435	0.1895
FP1_F7T	0.009531	1	14	0.0095	0.1307	0.7231	0.096	0.0092
FP2_F4T	0.018309	1	14	0.0183	0.4662	0.5059	0.180	0.0322
FP2_F8T	0.00366	1	14	0.0037	0.2967	0.5945	0.144	0.0208
F3_F4T	0.417437	1	14	0.4174	2.3482	0.1477	0.379	0.1436
F3_F7T	1.269777	1	14	1.2698	1.3854	0.2588	0.300	0.0900
F4_F8T	0.072159	1	14	0.0722	0.6675	0.4276	0.213	0.0455
F7_F8T	0.204587	1	14	0.2046	0.2818	0.6039	0.140	0.0197
FP1_FP2A	0.003393	1	14	0.0034	0.0216	0.8854	0.039	0.0015
FP1_F3A	5.707321	1	14	5.7073	1.5351	0.2357	0.314	0.0988
FP1_F7A	0.101045	1	14	0.1010	0.1764	0.6809	0.112	0.0124
FP2_F4A	1.060771	1	14	1.0608	2.5970	0.1294	0.396	0.1565
FP2_F8A	0.000644	1	14	0.0006	0.0020	0.9650	0.012	0.0001
F3_F4A	0.201854	1	14	0.2019	0.3706	0.5524	0.161	0.0258
F3_F7A	2.490873	1	14	2.4909	0.5100	0.4869	0.187	0.0351
F4_F8A	0.328329	1	14	0.3283	0.6464	0.4348	0.210	0.0441
F7_F8A	0.118702	1	14	0.1187	0.7419	0.4036	0.224	0.0503
FP1_FP2B	0.068857	1	14	0.0689	0.1821	0.6761	0.113	0.0128
FP1_F3B	0.005207	1	14	0.0052	0.0134	0.9093	0.031	0.0010
FP1_F7B	0.206655	1	14	0.2067	0.9923	0.3361	0.257	0.0662
FP2_F4B	0.00161	1	14	0.0016	0.0020	0.9648	0.012	0.0001
FP2_F8B	0.232595	1	14	0.2326	0.7231	0.4094	0.222	0.0491
F3_F4B	0.619713	1	14	0.6197	1.5754	0.2300	0.318	0.1011
F3_F7B	0.000155	1	14	0.0002	0.0008	0.9781	0.007	0.0001
F4_F8B	0.001301	1	14	0.0013	0.0005	0.9827	0.006	0.0000
F7_F8B	0.03591	1	14	0.0359	0.3533	0.5617	0.157	0.0246

Table 19

General Linear Model: Analysis of Variance on Post-treatment Referential and Sequential Phase Deviation Scores

Dependent Variable	Type III Sum of Squares	*df*	Error *df*	Mean Square	*F*	Sig. (Bonf. alpha = .001)	Effect Size *r*	Partial Eta Squared
FP1_FP2D	0.000321	1	14	0.0003	0.1011	0.7552	0.085	0.0072
FP1_F3D	0.000558	1	14	0.0006	0.1018	0.7544	0.085	0.0072
FP1_F7D	0.014915	1	14	0.0149	2.5400	0.1333	0.392	0.1536
FP2_F4D	0.009838	1	14	0.0098	0.3181	0.5817	0.149	0.0222
FP2_F8D	0.046818	1	14	0.0468	0.4035	0.5355	0.167	0.0280
F3_F4D	0.029563	1	14	0.0296	0.5505	0.4704	0.195	0.0378
F3_F7D	0.077562	1	14	0.0776	0.7581	0.3986	0.227	0.0514
F4_F8D	0.007493	1	14	0.0075	0.1001	0.7564	0.084	0.0071
F7_F8D	0.02578	1	14	0.0258	0.1995	0.6619	0.119	0.0141
FP1_FP2T	0.024659	1	14	0.0247	1.0658	0.3194	0.266	0.0707
FP1_F3T	0.047879	1	14	0.0479	1.7288	0.2097	0.332	0.1099
FP1_F7T	0.007014	1	14	0.0070	0.1447	0.7094	0.101	0.0102
FP2_F4T	0.281596	1	14	0.2816	4.4791	0.0527	0.492	0.2424
FP2_F8T	0.095172	1	14	0.0952	0.3513	0.5628	0.156	0.0245
F3_F4T	0.072647	1	14	0.0726	1.0037	0.3334	0.259	0.0669
F3_F7T	0.514986	1	14	0.5150	1.3127	0.2711	0.293	0.0857
F4_F8T	0.304359	1	14	0.3044	5.4973	0.0343	0.531	0.2820
F7_F8T	0.000156	1	14	0.0002	0.0005	0.9826	0.006	0.0000
FP1_FP2A	0.114286	1	14	0.1143	1.2753	0.2777	0.289	0.0835
FP1_F3A	0.257588	1	14	0.2576	0.7038	0.4156	0.219	0.0479
FP1_F7A	0.002209	1	14	0.0022	0.0010	0.9752	0.008	0.0001
FP2_F4A	0.014869	1	14	0.0149	0.1561	0.6987	0.105	0.0110
FP2_F8A	0.139502	1	14	0.1395	0.8402	0.3749	0.238	0.0566
F3_F4A	0.38599	1	14	0.3860	3.0253	0.1039	0.422	0.1777
F3_F7A	0.010201	1	14	0.0102	0.0349	0.8546	0.050	0.0025
F4_F8A	0.238297	1	14	0.2383	1.3904	0.2580	0.301	0.0903
F7_F8A	0.003615	1	14	0.0036	0.0561	0.8163	0.063	0.0040
FP1_FP2B	0.153419	1	14	0.1534	0.3304	0.5745	0.152	0.0231
FP1_F3B	0.17264	1	14	0.1726	0.5967	0.4527	0.202	0.0409
FP1_F7B	0.66657	1	14	0.6666	2.8979	0.1108	0.414	0.1715
FP2_F4B	0.393599	1	14	0.3936	0.9310	0.3510	0.250	0.0624
FP2_F8B	0.07458	1	14	0.0746	0.4956	0.4930	0.195	0.0342
F3_F4B	0.683516	1	14	0.6835	0.8638	0.3684	0.241	0.0581
F3_F7B	5.06E-06	1	14	0.0000	0.0000	0.9949	0.002	0.0000
F4_F8B	0.108262	1	14	0.1083	0.3486	0.5643	0.156	0.0243
F7_F8B	0.006192	1	14	0.0062	0.1985	0.6627	0.118	0.0140

Table 20

General Linear Model: Analysis of Variance on Post-treatment Referential and Sequential Coherence Deviation Scores

Dependent Variable	Type III Sum of Squares	df	Error df	Mean Square	F	Sig. (Bonf. alpha = .001)	Effect Size r	Partial Eta Squared
FP1_FP2D	0.264968	1	14	0.2650	2.9720	0.1067	0.418	0.1751
FP1_F3D	0.005805	1	14	0.0058	0.0412	0.8420	0.054	0.0029
FP1_F7D	0.098028	1	14	0.0980	0.4181	0.5283	0.170	0.0290
FP2_F4D	0.019044	1	14	0.0190	0.1629	0.6926	0.107	0.0115
FP2_F8D	0.142223	1	14	0.1422	1.3479	0.2651	0.296	0.0878
F3_F4D	0.014671	1	14	0.0147	0.0695	0.7960	0.070	0.0049
F3_F7D	0.573475	1	14	0.5735	2.8989	0.1107	0.414	0.1715
F4_F8D	0.404973	1	14	0.4050	2.1429	0.1653	0.364	0.1327
F7_F8D	0.96089	1	14	0.9609	2.4235	0.1418	0.384	0.1476
FP1_FP2T	0.182329	1	14	0.1823	2.1929	0.1608	0.368	0.1354
FP1_F3T	0.652814	1	14	0.6528	17.300	0.0010	0.743	0.5527
FP1_F7T	0.089028	1	14	0.0890	0.3788	0.5481	0.162	0.0263
FP2_F4T	0.176925	1	14	0.1769	3.2974	0.0909	0.437	0.1906
FP2_F8T	0.001227	1	14	0.0012	0.0280	0.8696	0.045	0.0020
F3_F4T	0.004586	1	14	0.0046	0.0193	0.8915	0.037	0.0014
F3_F7T	0.342225	1	14	0.3422	1.0719	0.3181	0.267	0.0711
F4_F8T	0.217098	1	14	0.2171	2.8509	0.1135	0.411	0.1692
F7_F8T	0.002268	1	14	0.0023	0.0032	0.9554	0.015	0.0002
FP1_FP2A	0.023371	1	14	0.0234	0.1017	0.7545	0.085	0.0072
FP1_F3A	0.539031	1	14	0.5390	0.7465	0.4021	0.225	0.0506
FP1_F7A	0.002876	1	14	0.0029	0.0111	0.9177	0.028	0.0008
FP2_F4A	0.029756	1	14	0.0298	0.0887	0.7702	0.079	0.0063
FP2_F8A	0.049478	1	14	0.0495	0.4472	0.5145	0.176	0.0310
F3_F4A	0.016851	1	14	0.0169	0.0645	0.8032	0.068	0.0046
F3_F7A	0.000538	1	14	0.0005	0.0009	0.9767	0.008	0.0001
F4_F8A	0.091015	1	14	0.0910	0.1187	0.7355	0.092	0.0084
F7_F8A	0.011949	1	14	0.0119	0.0541	0.8195	0.062	0.0038
FP1_FP2B	0.422988	1	14	0.4230	1.2382	0.2846	0.285	0.0813
FP1_F3B	0.087062	1	14	0.0871	0.3098	0.5866	0.147	0.0217
FP1_F7B	0.009875	1	14	0.0099	0.0290	0.8671	0.046	0.0021
FP2_F4B	0.007428	1	14	0.0074	0.0065	0.9369	0.022	0.0005
FP2_F8B	0.005522	1	14	0.0055	0.0313	0.8620	0.047	0.0022
F3_F4B	0.039353	1	14	0.0394	0.1235	0.7305	0.093	0.0087
F3_F7B	0.110432	1	14	0.1104	0.5854	0.4569	0.200	0.0401
F4_F8B	0.414575	1	14	0.4146	0.3995	0.5375	0.167	0.0277
F7_F8B	0.000555	1	14	0.0006	0.0188	0.8928	0.037	0.0013

Table 21

Number & Percentage of Abnormal Phase Z-scores Change from Pre- to Post-treatment NF

Placement	Subject	Moved Toward Reference Mean	Moved Away Reference Mean
Referential		***Number (Percentage)***	***Number (Percentage)***
	1	3 (100%)	0 (0%)
	2	2 (40%)	3(60%)
	3	3(100%)	0(0%)
	4	16(100%)	0(0%)
	5	10(91%)	1(9%)
	6	1(100%)	0(0%)
	7	3(75%)	1(25%)
	8	3(100%)	0(0%)
	Total	**41 (89%)**	**5 (11%)**
Sequential			
	1	2(50%)	2(50%)
	2	9(90%)	1(10%)
	3	11(100%)	0(0%)
	4	8(100%)	0(0%)
	5	6(100%)	0(0%)
	6	3(60%)	2(40%)
	7	1(100%)	0(0%)
	8	2(67%)	1(33%)
	Total	**32 (84%)**	**6 (16%)**

Table 22

Number & Percentage of Abnormal Coherence Z-score Change from Pre- to Post- treatment NF

Placement	Subject	Moved Toward Reference Mean	Moved Away Reference Mean
Referential		***Number (Percentage)***	***Number (Percentage)***
	1	37 (97%)	1 (3%)
	2	11 (44%)	14(66%)
	3	24(75%)	8(25%)
	4	32(84%)	6(16%)
	5	41(84%)	8(16%)
	6	38(61%)	24(39%)
	7	25(83%)	5(17%)
	8	29(91%)	3(9%)
	Total	**237 (78%)**	**69 (22%)**
Sequential			
	1	0(0%)	4(100%)
	2	22(51%)	21(49%)
	3	17(43%)	23(57%)
	4	5(83%)	1(17%)
	5	25(86%)	4(14%)
	6	26(72%)	10(28%)
	7	16(100%)	0(0%)
	8	6(67%)	3(33%)
	Total	**117 (64%)**	**66 (36%)**

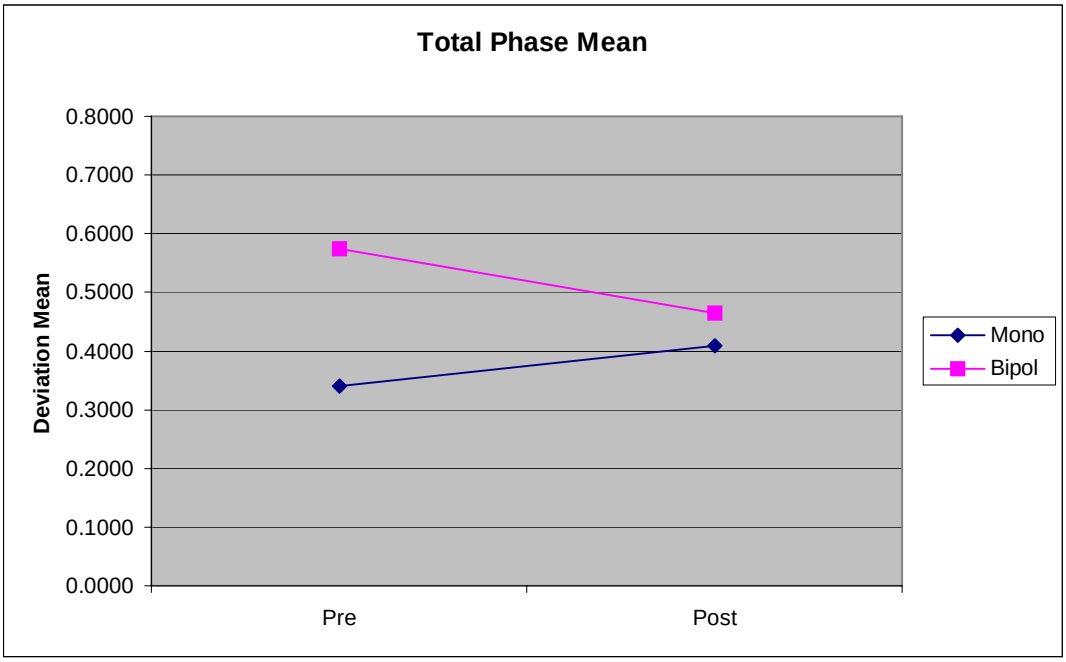

Figure 1. Total pre- and post- treatment phase deviation score mean for referential (Mono) and sequential (Bipol) placement.

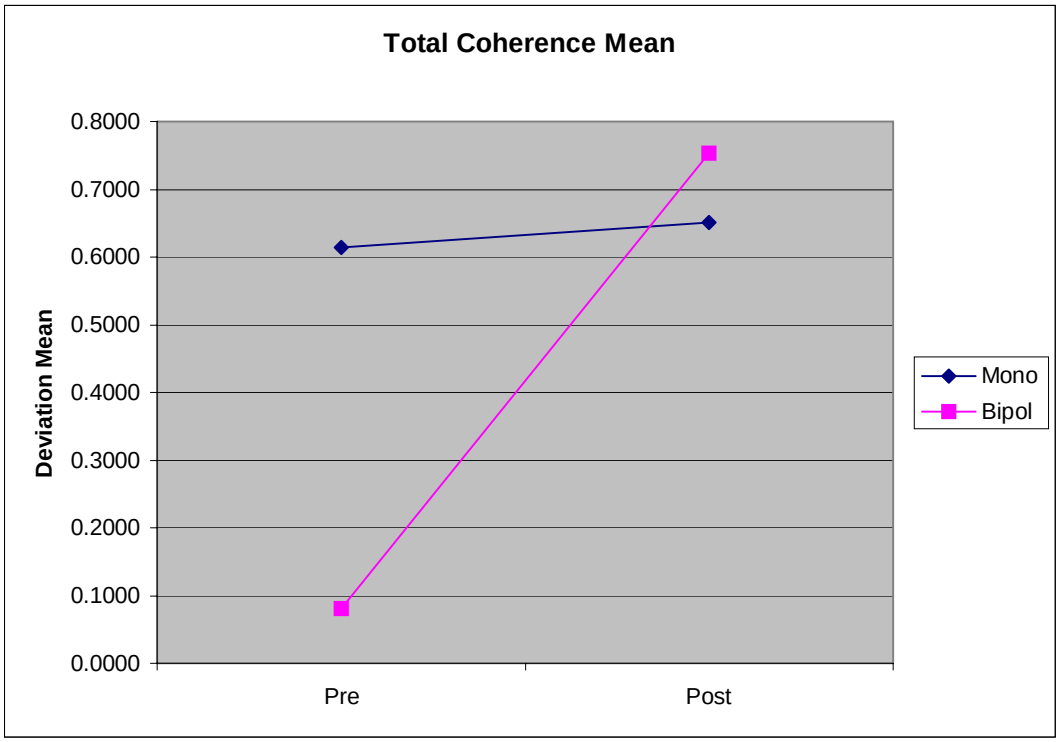

Figure 2. Total pre- and post- treatment coherence deviation score mean for referential (Mono) and sequential (Bipol) placement.

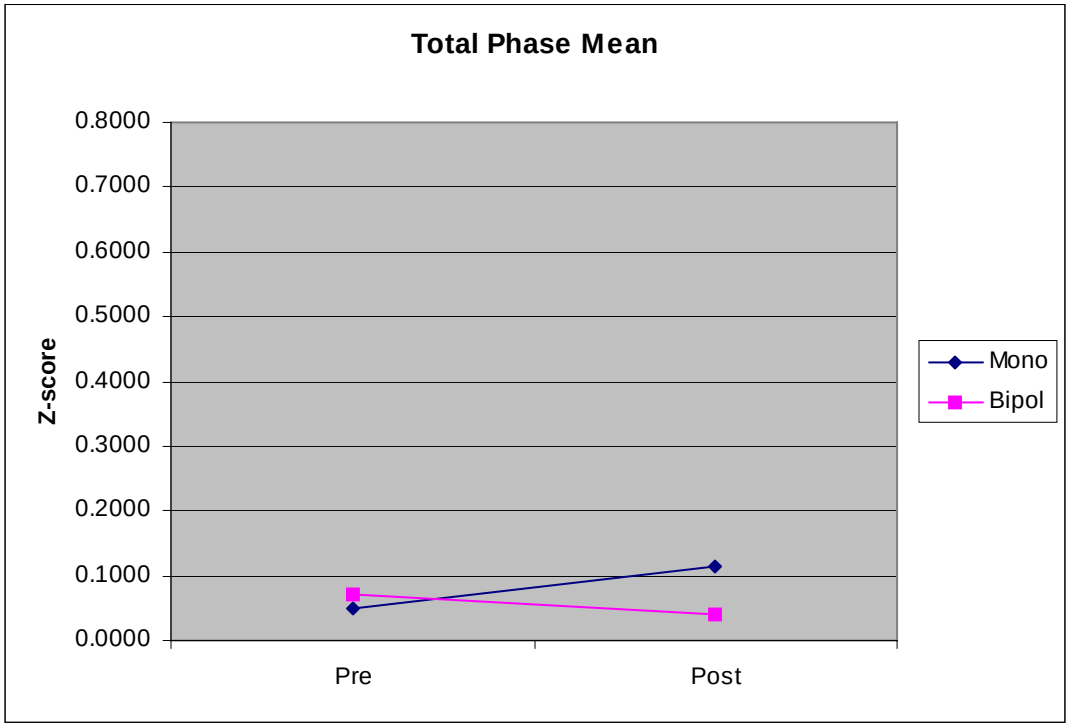

*Figure 3.*Total pre- and post- treatment phase *z*-score mean for referential (Mono) and sequential (Bipol) placement.

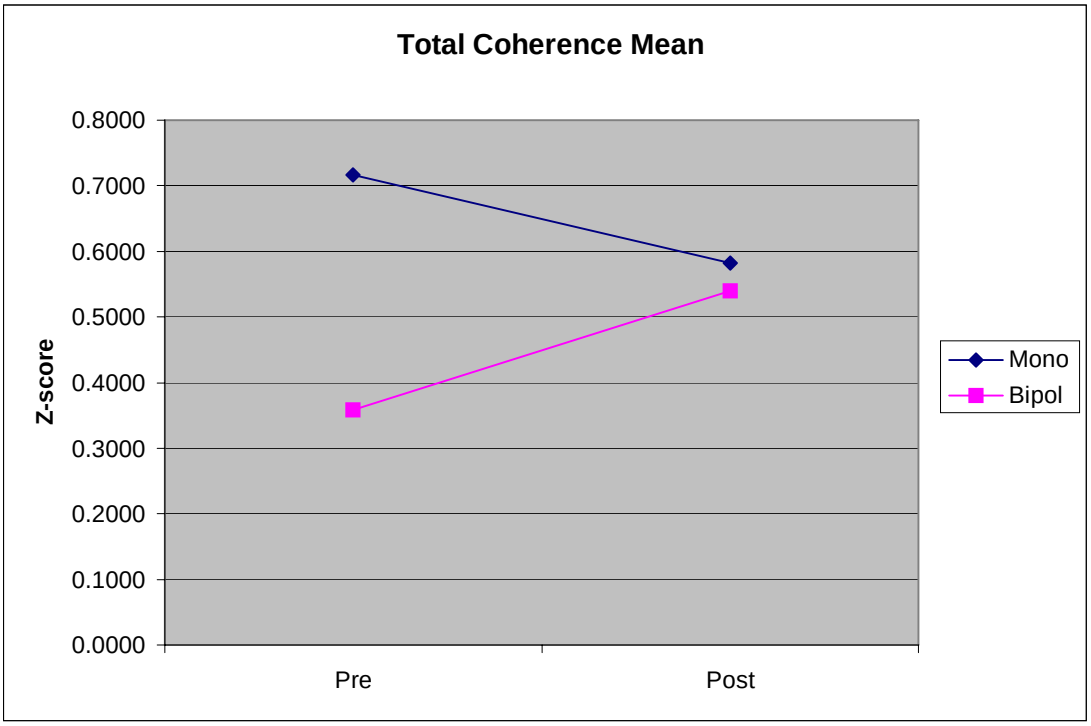

Figure 4.Total pre- and post- treatment coherence *z*-score mean for referential (Mono) and sequential (Bipol) placement.

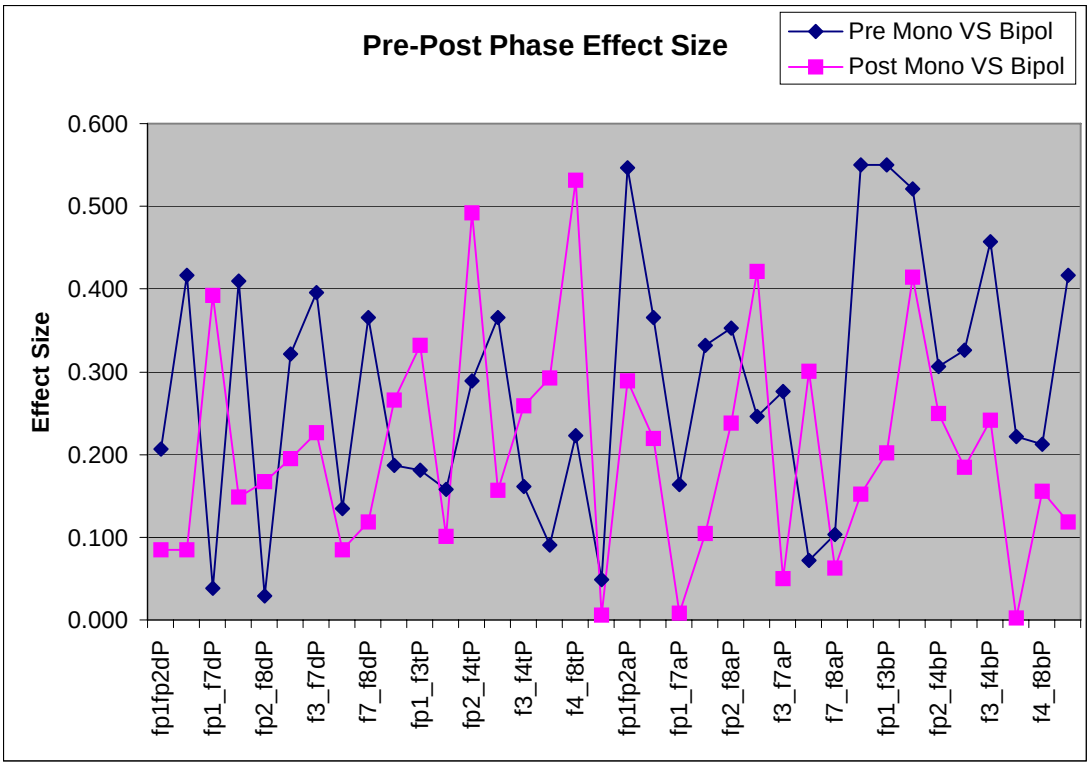

Figure 5. Differences between referential (Mono) and sequential (Bipol) placement groups show that effect sizes decrease at post- compared to pre-treatment. This indicates that large differences between referential and sequential placement groups existed at pre-treatment comparison, and as NF was introduced, differences decreased at post-treatment comparison.

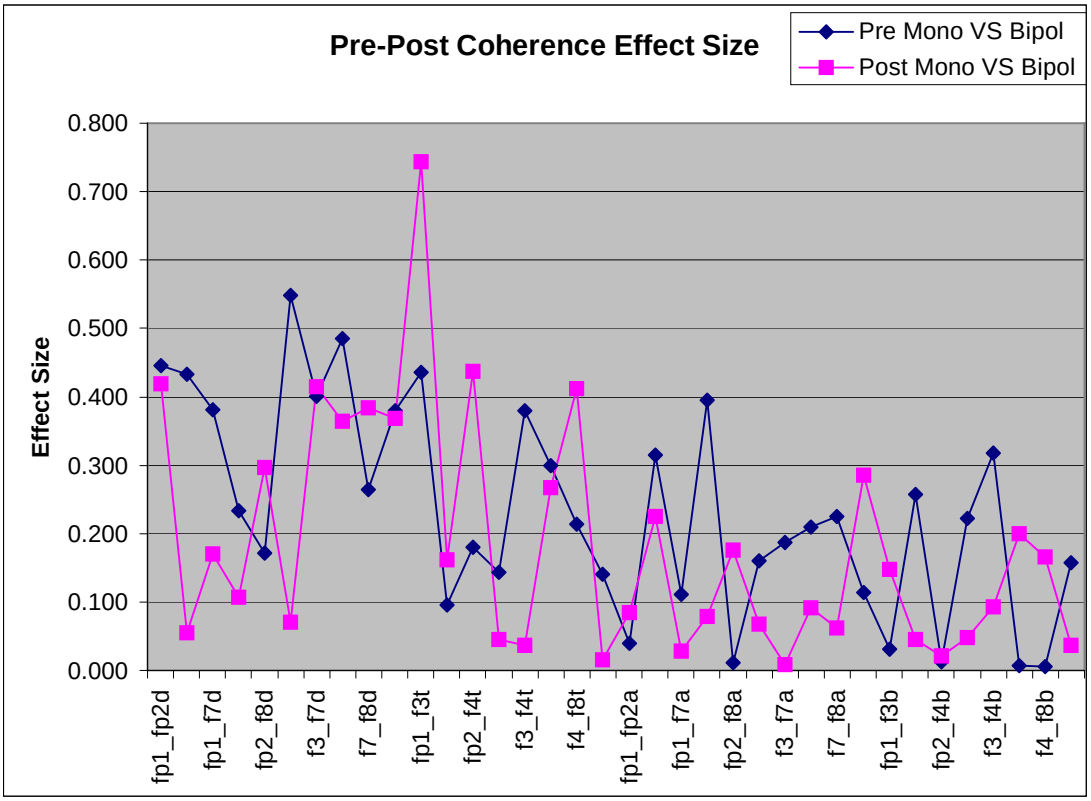

Figure 6. The same relationship observed in the phase effect size values was also observed in the coherence effect size values.

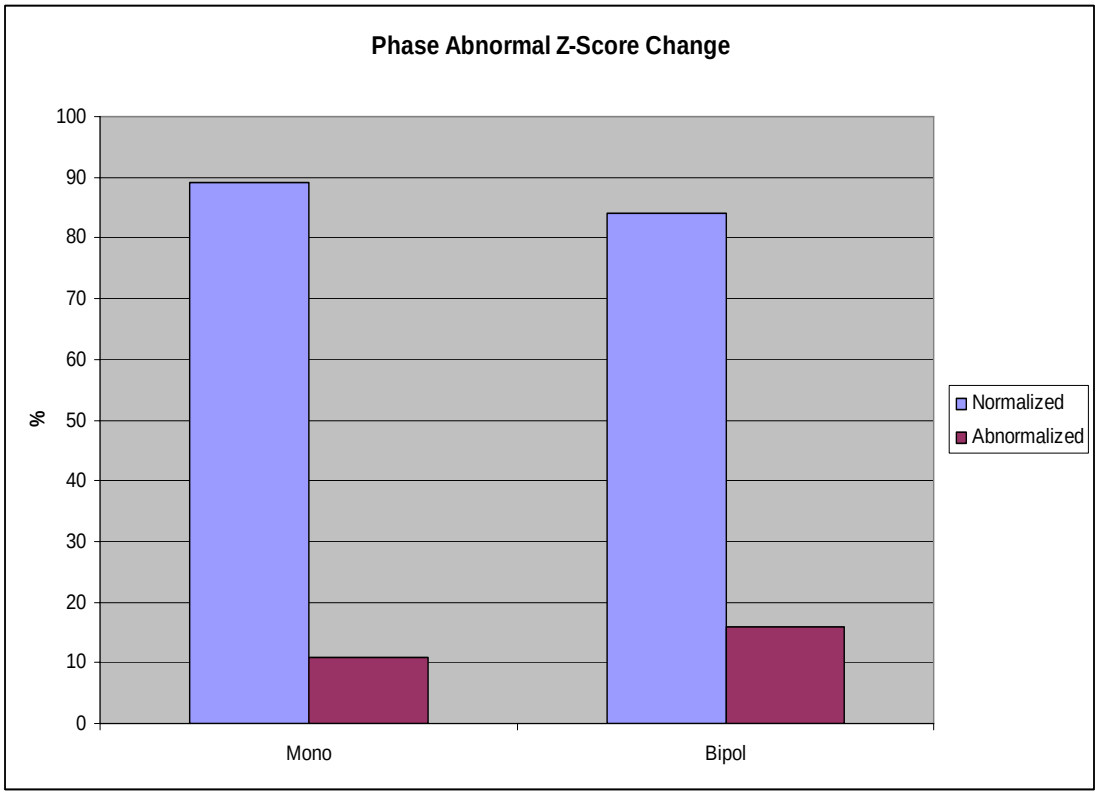

*Figure 7. A*lmost all of the abnormal phase *z*-scores moved toward the reference database mean.

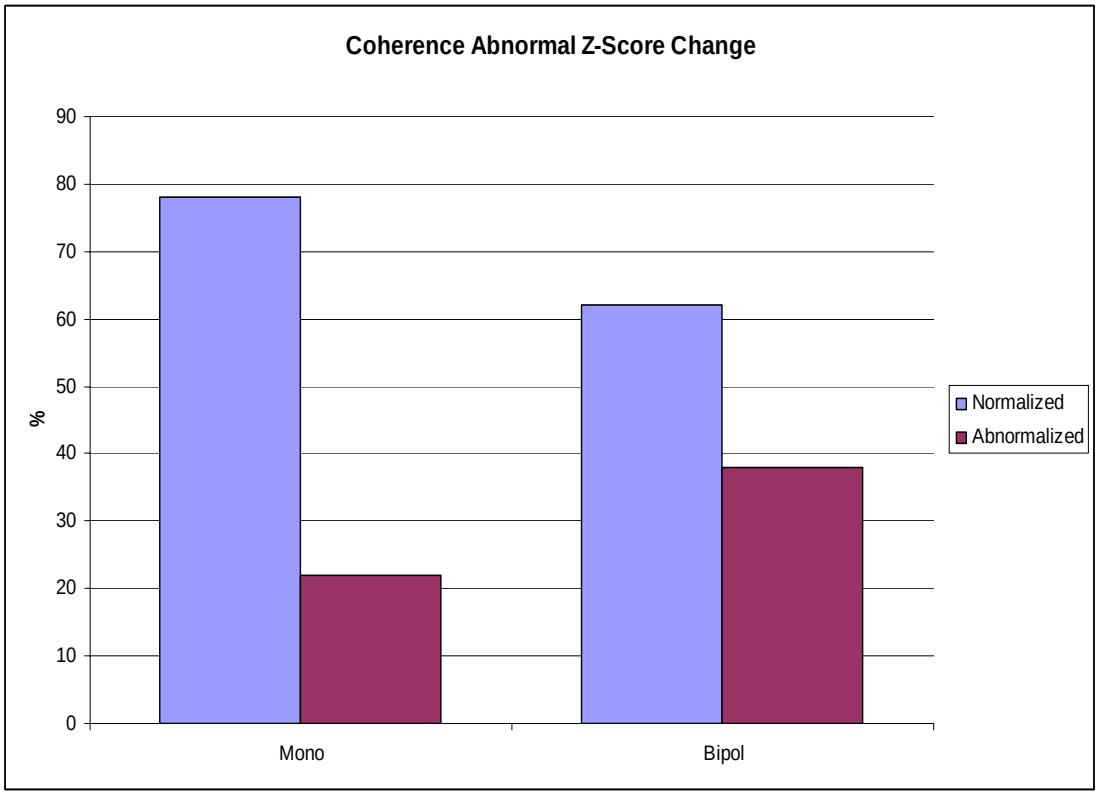

Figure 8. Less percentage of abnormal sites moved toward the reference database mean in the coherence *z*-scores than the phase *z*-scores.

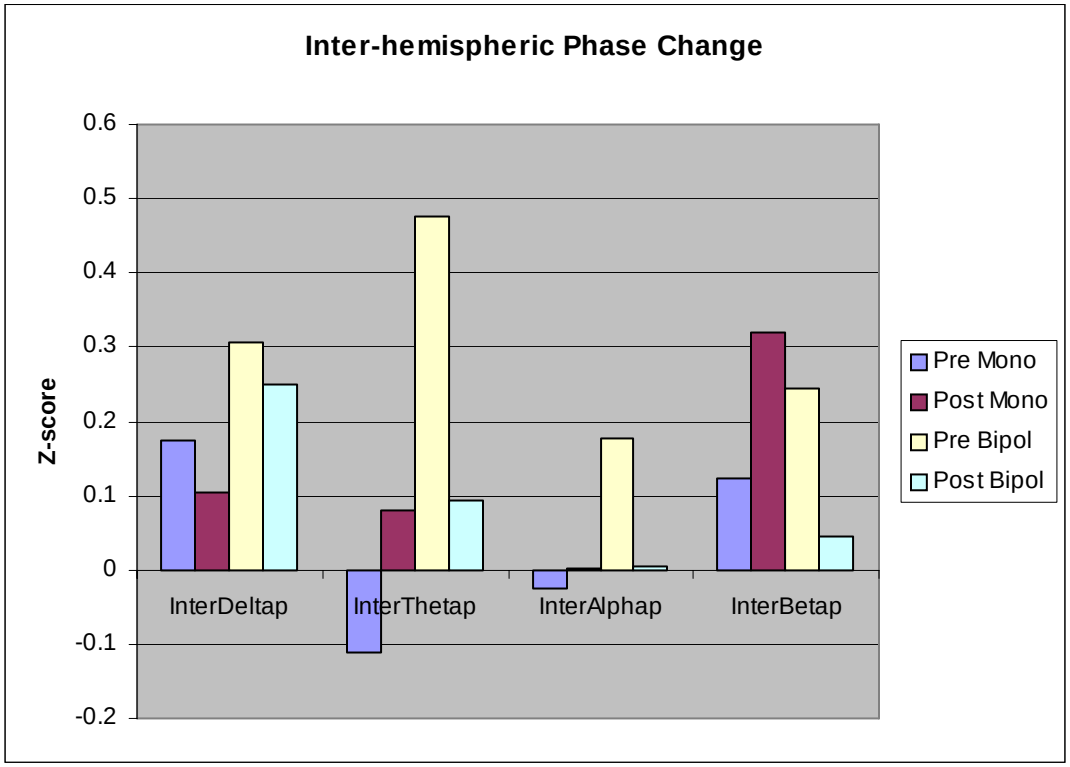

Figure 9. Inter-hemispheric sites comprised of Fp1-Fp2, F3-F4, and F7-F8 for phase measure. Inter-hemispheric phase *z*-score means show that referential placement (Mono) tends to decrease phase after NF amplitude training in the delta, theta, and alpha frequencies but increases phase in the beta frequency. Sequential placement (Bipol) tends to decrease phase after NF amplitude training in the delta, theta, alpha, and beta frequencies.

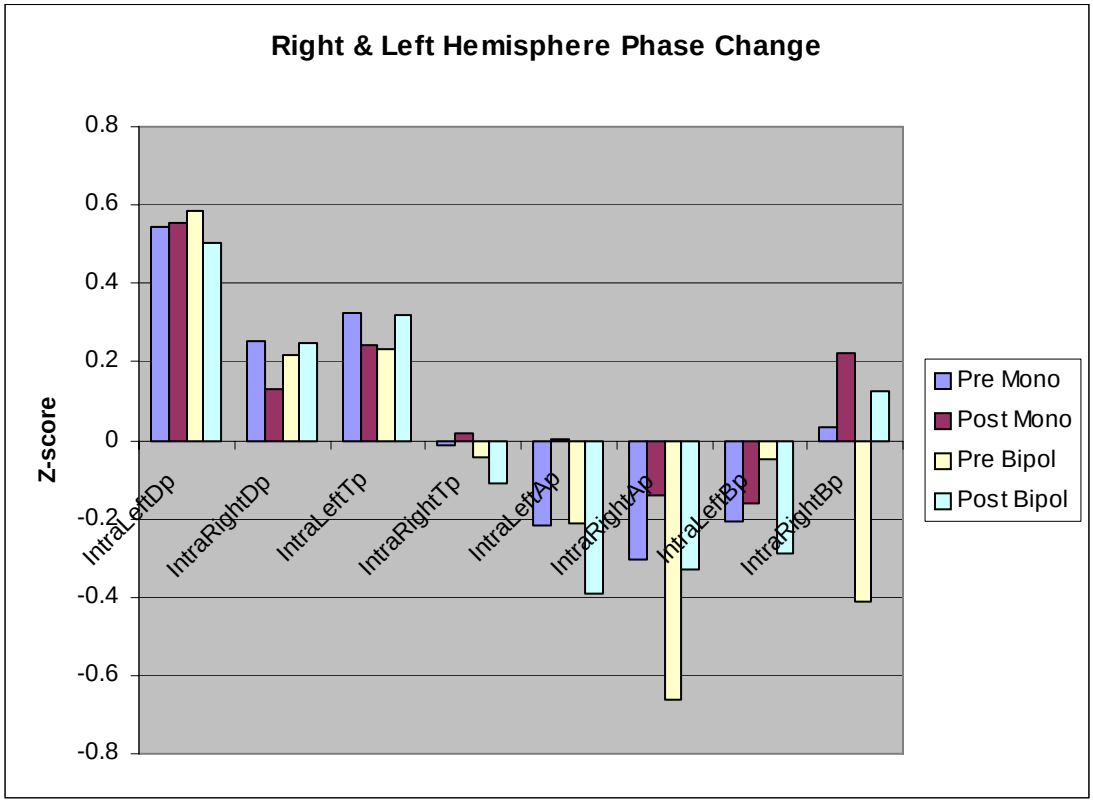

Figure 10. The left hemispheric sites comprised of Fp1-F3, F3-F7, and Fp1-F7, while the right hemispheric sites comprised of Fp2-F4, F4-F8, and Fp2-F8 for phase measure. No consistent pattern was present for phase scores.

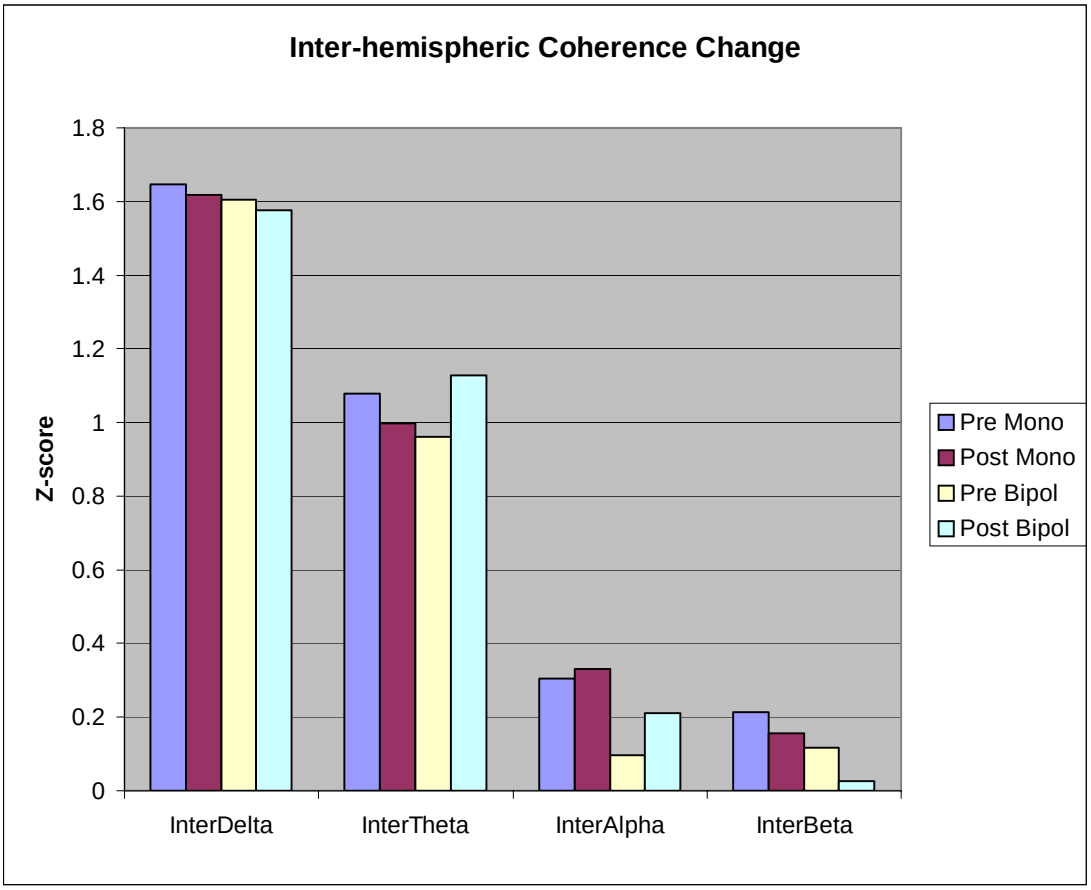

Figure 11. Inter-hemispheric sites comprised of Fp1-Fp2, F3-F4, and F7-F8 for coherence measure. Inter-hemispheric coherence *z*-scores means show that referential placement (Mono) tends to decrease connectivity after NF amplitude training in the delta, theta, and beta frequencies but increases connectivity in the alpha frequency. Sequential placement (Bipol) tends to decrease connectivity after NF amplitude training in the delta, and beta frequencies, but increase connectivity in the theta and alpha frequencies.

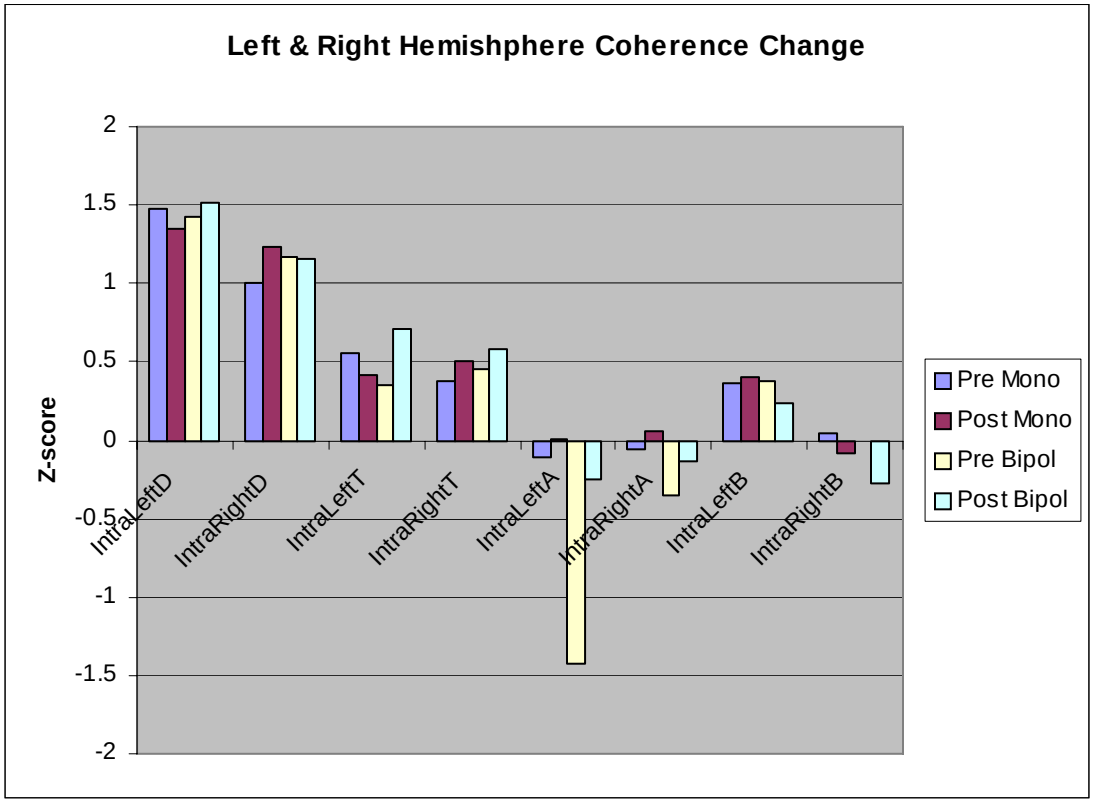

Figure 12. The left hemispheric sites comprised of Fp1-F3, F3-F7, and Fp1-F7, while the right hemispheric sites comprised of Fp2-F4, F4-F8, and Fp2-F8 for coherence measure. No consistent pattern was present for coherence scores.

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