

RECOGNITION OF CONCEALED INFORMATION
WITH BEHAVIORAL AND SPECTRAL
ANALYSES

By

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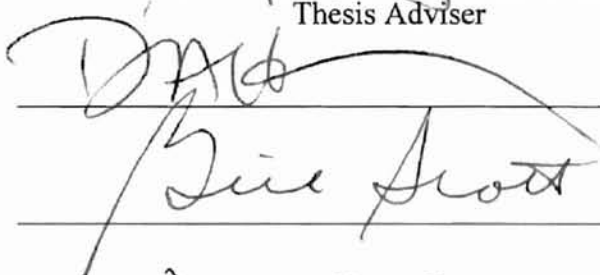
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PREFACE

The main thesis of this project was that individuals who have concealed information can be detected using a combined behavioral and psychophysiological approach. This study examined the similarities and differences that characterize the behavioral and power spectra responses in truthful and deceptive subjects. Half of the subjects participated in a mock crime while the other half participated in a non-crime scenario. The participants responded during their session to words related and not related to the scenarios they enacted. Although the participants in the crime group were instructed to deny anything related to their scenario, the behavioral and spectral data demonstrate that they actually possess concealed information. Therefore, behavioral and spectral indices elicited by concealed information in deceptive subjects can reflect some aspects of deceit.

I wish to express my appreciation to my major advisor, Dr. Marc E. Pratarelli for his intelligent supervision, constructive guidance, inspiration and friendship. My sincere appreciation extends to my other committee members Dr. Doug Hershey and Dr. Bill Scott, whose assistance are also invaluable.

More over, I wish to express my sincere gratitude to those who provided suggestions and assistance for this study: Mr. Blaine Browne, Mr. Son Le, and Ms. Jennifer Blakley.

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Chapter I

The search for an accurate and reliable way to detect deception has occupied the time of many researchers and criminologists since the beginning of modern civilization. In particular, for the past several decades, the polygraph has been used as a tool for detecting deceit. However, research has shown that the polygraph has low validity and reliability (Bashore & Rapp, 1993; Kleinmuntz & Szucko, 1982). The problems with the use of the polygraph include using autonomic physiological indicators to detect a cognitive process, subjective influences involved in interpreting the polygraph recordings, detecting the use of physical or mental countermeasures, and the polygraph's requirement of a cooperative subject. Recently, several psychometric electrophysiological devices that measure central nervous system activity, e.g., electroencephalograms (EEGs) have been studied in the hopes of locating a specific cognitive process that indexes deception (Bashore & Rapp, 1993; Rosenfeld, Nasman, Whalen, Cantwell, & Mazzeri, 1987). Although an accurate and reliable way to use the EEG has not yet been found, future prospects of using it to distinguish deception from nondeception seems promising. The thesis of this proposal is to continue exploring possible electrophysiological indices of deception using behavioral and EEG responses in truthful and deceptive subjects who are presented words related and not related to the scenarios they enact.

An external means of detecting deceit has been an issue that many people have tried to accomplish. Trovillo (as cited in Ford, 1995) discussed how nonconventional techniques used to detect deceit have ranged from eating certain foods or licking hot iron,

to devising elaborate devices of torture. More conventional techniques have also been explored, however. These approaches tend to gain information either from voluntary observable behavior such as smiling or involuntary observable behavior such as sweating, eye blinks, and heart rate. Also, several techniques have been used simultaneously in order to increase the accuracy of detecting deception. For instance, polygraph tests tend to record several autonomic physiological processes simultaneously. These include cardiovascular, electrodermal, respiratory, and pupillary measures (Bradley & Janisse, 1981; Elaad, Ginton, & Jungman, 1992). However, no measurement or combination of measurements have yet been able to detect deception with high accuracy.

Traditional Approaches to Lie Detection

Conventional approaches to the psychophysiological detection of deception (PDD) all revolve around the use of the polygraph. The polygraph is a PDD tool that implicitly examines the differences between physiological reactions to deceptive and nondeceptive responses by the subject to probing questions regarding the issue being addressed. The physiological reactions occur when the sympathetic autonomic nervous system (SANS) is aroused and when adrenergic neurotransmitters are released into the blood stream (Ford, 1995). SANS and adrenergic neurotransmitter activity are found by recording physiological responses such as heart rate and electrical conduction in the skin (Ford, 1995). In addition, several behavioral variations of polygraph examinations have been developed. These include the Relevant Question (Relevant-Irrelevant) Test (Marston, 1917), Comparison Question Test (Reid, 1947), Guilty (Concealed) Knowledge Test (Lykken, 1959), and Directed Lie Control Test (Honts & Raskin, 1988).

The polygraph examination assumes that autonomic processes respond differently during deception versus nondeception. PDD measures have been found to discriminate between deception and nondeception at a rate higher than chance, but no physiological response has been found that is directly related to deception (Elaad, 1994; Bradley & Janisse, 1981). Moreover, SANS activity and adrenergic neurotransmitters respond differently to many cognitive and emotional processes including anxiety, sensitization, fear, and anger (Ford, 1995; Kleinmuntz & Szucko, 1982). Thus, the assumption that conventional PDD approaches actually measure deception give the polygraph questionable validity (Kleinmuntz & Szucko, 1982).

The Relevant Question (relevant-irrelevant) Test (RQT) developed by Marston (1917) is the oldest type of technique used in polygraph examinations (Ford, 1995). The RQT involves obtaining a baseline by asking several neutral questions. Once a baseline is obtained, a question relevant to the purpose of the examination is asked. For instance, a polygraph examination might ask irrelevant questions such as "How old are you?" and record different physiological responses in order to generate a baseline concerning the level of physiological reaction to truthful responses. Then, the polygraph examiner might ask several questions relevant to a criminal act such as "Have you ever stolen any equipment from your employer?" The polygraph examiner detects deception by comparing the baseline physiological reactions from irrelevant questions with physiological reactions to relevant questions. If the baseline reactions and relevant physiological reactions differ significantly, then the subject is determined to be lying.

The use of the RQT declined because a more valid PDD tool, known as the Control Question Test, was discovered.

The Comparison Question Test (CQT) developed by Reid (1947) and originally termed the Control Question Test, is currently the most common technique used in polygraph examinations (Ford, 1995). The CQT is similar to the RQT and involves asking examinees several control questions in which they are likely to lie. For example, the question "Have you ever lied to another person?" might be assumed to force the subject to lie. Then, irrelevant questions that are not intended to elicit a deceptive response are asked. Finally, questions relevant to the purpose of the examination are asked. Physiological responses between control and irrelevant questions are examined and differences in response levels are assumed to be caused by deceptive versus nondeceptive states. Examinees who have greater physiological reactivity to relevant questions than irrelevant questions are determined to be lying. Recently, control questions were redefined as comparison questions by polygraph practitioners.

One problem with the CQT is the assumption that certain questions will always elicit a deceptive response. This assumption holds that during an interrogation, the subject is fearful of admitting to any criminal or immoral act and therefore will lie to the investigator, even though virtually every person has committed the act (Ford, 1995). This faulty assumption, along with the assumption that autonomic reactions detect deception is probably why the CQT has a false-positive error rate between 36 and 39 percent (Kleinmuntz & Szucko, 1982). Obtaining a baseline on the assumption that everyone lies to certain questions is the basis for calling the CQT a subjective test (Ford, 1995).

An alternative to the CQT, known as the Guilty Knowledge Test (GKT), was introduced by Lykken (1959). The GKT involves asking a subject multiple choice questions based on factual knowledge gathered from a crime. One alternative to each question is relevant to the crime while the other alternatives are unrelated. A physiological indicator compares the autonomic reactions of the crime-relevant alternative to the autonomic reactions of other crime-nonrelevant alternatives in order to determine deception. The GKT does not assume that physiological reactions measure deception. The assumption in the GKT is that physiological measures detect guilt because autonomic arousal related to remembering the criminal act will occur in a guilty subject (Bashore & Rapp, 1993). The GKT appears to correctly identify deceptive versus nondeceptive subjects around 88 percent of the time, with a false positive error rate between five and zero percent, and a false negative error rate of around 12 percent (Kleinmuntz & Szucko, 1982; Bashore & Rapp, 1993).

Although the GKT seems to be highly predictive of guilt, it is not applicable in 90 percent of the cases in which the polygraph can be used (Kleinmuntz & Szucko, 1982). The GKT requires that the polygrapher have specific knowledge of the crime (Ford, 1995). Because the GKT requires specific information about an act for which an examinee might be guilty, it can not be used with general honesty and integrity checks. The GKT can only be used when an act has been performed from which evidence can be collected. Since the GKT could only detect guilt in limited situations, it did not become widely used in the field of lie detection.

A second alternative to the CQT, known as the Directed Lie Control Test (DLC), was developed by Fuse (as cited in Raskin, 1989) and formalized by Honts and Raskin (1988). The DLC is similar to the CQT in that both tests are interpreted in the same way and that the polygraph examiner asks several control or comparison questions to elicit a deceptive response, nonrelevant questions that elicit a nondeceptive response, and relevant questions related to the deceptive act in question. However, the DLC does not assume that control questions alone will elicit a deceptive response. Therefore, the examiner instructs subjects to lie to the control questions and think about an instance when they committed such a deceptive act. For instance, an examinee might tell a subject to lie to the question, "did you ever lie during your teenage years?", and also think about a particular instance when a lie was committed as a teenager. Proponents of the DLC suggest that it will accurately detect deception because all subjects tend to focus on the questions that determine guilt from innocence (Raskin, 1989). Truthful subjects should have enhanced concern on the control questions while deceptive subjects should focus on the relevant questions in which they lie.

Honts and Raskin (1988) conducted a field study using the DLC using 25 criminal suspects. Their results revealed that 92 percent of guilty-innocent decisions were correct with a false positive error rate of approximately 20 percent and a false negative rate of approximately eight percent. Also, the DLC was found to be more time efficient, far easier to administer, and could be applied to many testing situations. Presently, the DLC appears to be a more accurate PDD measure than the CQT, but further research needs to be conducted in order to establish the validity and reliability of the DLC.

New Approaches to PDD

In response to the weak validity and reliability of PDD measures, researchers have recently begun examining EEGs in the hopes of finding a better tool for the detection of deception or concealed information. EEGs have two main advantages over PDD measures. First, EEGs measure cognitive processing where it actually takes place, in the central nervous system (CNS). Because deception is a cognitive process, potential confounds concerning a subject's emotional state or anxiety may not pollute the EEG data as severely. Conventional PDD measures are not able to control for emotions or anxiety. Secondly, EEG data does not rely heavily on subjective procedures or interpretations from the examiner concerning the detection of deceit. EEG data have been found to be a reliable measure of cognitive processing despite differing levels of examiner skill (Bashore & Rapp, 1993).

Studies examining the use of EEGs as an index of deception have focused on event-related brain potentials (ERPs) (Bashore & Rapp, 1993; Kleinmuntz & Szucko, 1982). ERPs are measures of brain electrical activity that are recorded at the scalp using several samples (epochs) of an EEG signal averaged together. In many cases, up to 200 epochs might be averaged together to produce a single ERP. The EEG signals are recorded using electrodes placed on the scalp which measure changes in electrical activity within the brain. Cognitive processes may be measured using ERPs by examining average changes in the signal polarity and the time (in milliseconds) over which the changes in electrical activity take place. The process of averaging electrical signals as a function of time allows researchers to average out activity that is not correlated with the

time-locked presentation of the stimulus (Pratarelli, 1991). The remaining, correlated electrical signals are referred to as the ERP. The ERP has been shown to represent several synchronized neuronal populations whose processing is related specifically to the time-locked presentation of the stimulus. A common distinction between early-onset and later onset ERPs is to refer to them as either exogenous (reflecting early sensory processing) or endogenous (reflecting perceptual and cognitive processing). Endogenous potentials can be further subdivided into automatic cognitive processing and conscious-controlled processing. Potentials related to conscious-controlled processing are manipulated by psychological and cognitive variables, while automatic cognitive processing can not be consciously manipulated by the subject. For instance, attention is a conscious-controlled process that the subject can direct. Alternatively, the early stages of stimulus recognition are processes that are performed without the subject's attention or awareness.

The polarity of the ERP is either positive or negative, and specific potentials change as a function of the specific cognitive processes recruited following the presentation of the stimulus. Most ERPs are labeled using the symbols "P" or "N" representing the positive or negative polarity of the wave, and a number or numbers representing the placement of the wave in relation to stimulus onset. For example, P300 and N4 represent specific ERPs. P300 represents a positive wave that peaks around 300 ms, and N4 represents the fourth negative wave following the onset of a stimulus. However, there are many occasions in which P300 and N4 can be represented as P3 and N400, respectively. The most efficacious convention to use is the actual time, in

milliseconds, where the number represents the latency of the peak of the waveform in question. For instance, while N400 represents a class of ERPs, a particular N400 from any given study could be represented as N450 (Pratarelli, 1994).

Previous ERP research in detecting deception has focused on the P300 and N400 windows (Allen, Iacono, & Danielson, 1992; Boaz, Perry, Raney, Fischler, & Shuman, 1991; Farwell & Donchin, 1991; Rosenfeld et al., 1987; Rosenfeld et al., 1988; Stelmack, Houlihan, & Doucet, 1996). These studies have focused on detecting deception by examining familiar, unfamiliar, and probe stimuli in view of a subject's behavioral response to the stimuli.

Rosenfeld et al. (1987) examined differences in poststimulus ERPs between 400 and 700 ms related to a chosen item and eight novel items. A mock crime involving theft was constructed and subjects were asked to take one item out of a box containing nine items. Following the mock theft, ERPs were recorded while subjects were shown words on a screen of their chosen item, as well as eight novel items that they had not previously seen. Results revealed a significant difference ($p < .001$) between the ERP averages concerning chosen versus novel items. Specifically, positive peaks, either being distinct P300 waves or a broad positive area, were found in response to chosen items. However, novel item responses did not show consistent positivity during the critical time period. Thus, ERPs reveal that cognitive processing of verbal stimuli is different for familiar versus relatively unfamiliar stimuli. Rosenfeld et al.'s (1987) finding supports previous studies concerning an oddball paradigm in which a familiar item evokes a P300 when being contrasted with several non-familiar stimuli (Duncan-Johnson & Donchin, 1977).

Farwell and Donchin examined crime-related scenarios and subjects with a criminal past history to explore whether the P300 could accurately detect deception (1991). Two groups of subjects were used where each group was guilty of committing one mock crime, but not the other. Stimuli consisted of phrases relevant to each scenario and phrases that each subject rehearsed and was instructed to detect. Results found the P300 index distinguished between familiar and unfamiliar phrases by being elicited to familiar phrases only. Also, using a bootstrapping procedure, the P300 distinguished between familiar and unfamiliar phrases in 83 percent of the trials.

The N400 component of ERPs has been found in response to unexpected or inappropriate linguistic or semantic contextual violations (Kutas & Hillyard, 1980; Pratarelli, 1994; Boaz et al., 1991). For example, “roses are red” is a common phrase with red being commonly associated with roses but, “roses are black” is a contextual violation since roses are not commonly associated with the color black. In lie detection, the N400 should be elicited when a participant with knowledge of a crime related event is given a false sentence related to that crime, i.e. a contextual violation relative to that crime. The N400 should not be elicited if a participant does not have knowledge of a crime related event (Boaz et al., 1991).

Spectral Analysis and Detection of Concealed Information

Rhythmic activity comprises much of the resting EEG (Salansky, Fedotchev, & Bondar, 1995). This rhythmic activity is a function of the collective oscillations generated by groups of neurons firing in synchronous patterns. These patterns of neuronal firing can be studied using a procedure called spectral analysis. Spectral

analysis is the process of taking a time epoch from the EEG waveform and breaking it down into components related to the frequency domain (Wong, 1991). Decomposition of a time epoch into spectral components is usually performed using a digital algorithm known as the Fast Fourier Transform, or FFT (Salansky et al., 1995). Common frequency bands include alpha rhythms (8 - 13 Hz) which are often associated with relaxation, beta rhythms (13 - 30 Hz) that are considered to reflect active mental processing, theta (4 - 8 Hz), and delta (1 - 4 Hz) rhythms; the latter two are associated with underarousal (Andreassi, 1989). Power spectral analysis of the EEG has been utilized in other research, including development of diagnostic criteria, pathological brain states, attention, and learning disabilities (Ackerman, Dykman, Oglesby, & Newton, 1994; Oatman, 1982; Salansky et al., 1995). Figure 1 represents a typical power spectrum plot after FFT analysis.

The purpose of the current study is to examine possible spectral indicators of deception vs. nondeception in the context of a mock crime. Possible spectral indicators of deception are frequency, amplitude, and electrode location. In the present study, there is some reasonable expectation that beta waves might index deception since they reflex mental processing (Andreassi, 1989).

Presently, a mock crime was examined in which half of the subjects committed an act of espionage. The second half of subjects performed a scenario involving an errand not related to the espionage scenario and that did not contain any deceptive manipulations. However, all participants were examined concerning the espionage case. Thus, the espionage group was guilty of the crime in question while the errand group did

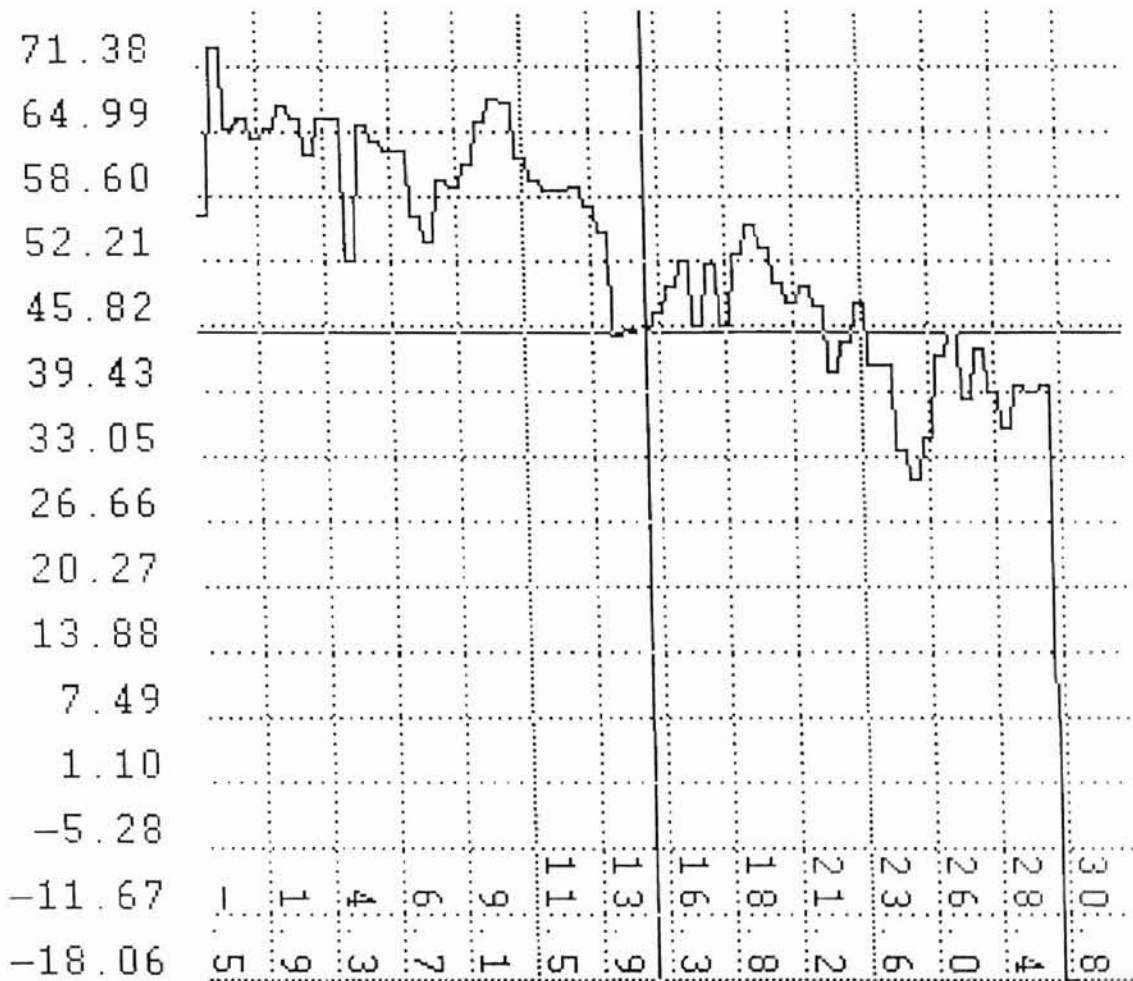


Figure 1. An example of a power spectrum plot. Power spectrum is examined using relative magnitude, in decibels along the Y axis, and frequency, in hertz along the X axis.

not have any knowledge of the crime. The espionage group was instructed to attempt to deceive the examiner while the errand group was instructed to be truthful. Examiners involved in detecting deception presented themselves as not having any knowledge of whether subjects were deceptive or nondeceptive and all subjects were directed to withhold such information from the examiner.

The current study is important in that it expands the existing knowledge base concerning the use of EEG as a tool for the detection of concealed information. This was done by examining whether a spectral indicator of deception exists. PDD tools used in the detection of deception assume that changes in physiological reactions indicate deception. However, physiological reactions can be influenced by a number of cognitive, motor, and emotional factors. Thus, PDD tools such as the polygraph are not necessarily good indicators of a specific cognitive process generated by the central nervous system. EEGs tend to have more accurate and reliable measures of deception than current PDD measures. However, the use of spectral EEG as a tool for the detection of deceit has not been examined.

The chief problem with detecting deceit is that deception is a conscious and intentional process under most formal circumstances. Therefore, deceit can be controlled by the individual. Outside the laboratory, subjects can choose or not choose to cooperate with tools and examiners who detect deception. Therefore, an indirect means of detecting concealed information is required to more accurately detect deception. Although the detection of familiarity versus nonfamiliarity of crime related information is not a direct

measure of deceit, the use of EEG to detect familiarity of stimuli is a modest improvement over current PDD measures.

Hypotheses

The principal concerns of this thesis are the EEG differences between deceptive and nondeceptive processing to crime relevant and irrelevant stimuli. Therefore, the main hypothesis is that differences should appear between relevant and irrelevant spectral EEG responses as-well-as behavioral responses. Relevant responses are related to the particular scenario that a subject performs while irrelevant responses are related to the scenario that a subject does not perform. Also, there should be detectable differences between those subjects who participate in the mock crime, and those who do not. These differences should exist because the experimental subjects (i.e., those who commit the crime) are directed to lie.

A secondary concern in this thesis is to examine the behavioral and EEG differences between personally familiar words and foils (novel words), and whether these two differ from the irrelevant words from the two scenarios for each respective group. Since both personally familiar and foil words are not instrumental with regard to enacting either scenario, or in the directed lying, these conditions should elicit similar behavioral and EEG responses from both subject groups.

Chapter II

Method

Participants

Twenty participants were solicited from the Oklahoma State University undergraduate population. They were screened for right handedness, English as a first language, normal or corrected to normal vision, neurological disorders, learning disabilities, and prior experience in a mock crime scenario or with lie detectors. Also, participants were read an information form concerning the study and completed an attached consent form indicating their agreement to participate in the study. Subjects were evenly divided, but randomly assigned, into an experimental group or a control group. The experimental group consisted of 10 subjects who enacted a mock crime involving espionage. The control group consisted of 10 subjects who performed a mock scenario involving an errand that did not contain any deceptive manipulations. Participants received extra-course credit for their participation in the study.

Apparatus for Spectral EEG Data

Subjects were fitted with a stretch forming electrode cap (Electro-Cap, International) imbedded with seven EEG tin electrodes. The recording sites included the International 10/20 system locations Cz and Pz at the midline and F7, F8, T3, and T4 sagittal of the midline. An additional electrode used for eye-artifact rejection was placed below the left eye. All electrode impedance were below five Kohms and variances between the reference electrodes were no more than 10 %.

EEG amplification filter constants were set at 0.1 and 30 Hz. This prevents the aliasing of brain and muscle artifact at frequencies beyond the cutoff. EEG was recorded and digitized using the WinDaq software provided by DataQ Instruments, Inc.. Individualized artifact thresholds were calibrated so that any trials containing eye blinks or excessive horizontal eye movement were rejected prior to analysis. Trials which passed artifact rejection criteria were sorted by trial-type condition. For every subject, three randomly selected artifact-free two second epochs for each condition underwent a Hamming window tapering and FFT analysis. The FFT yielded plots of power for each subject in each condition and for each electrode site. Frequency and amplitude data were recorded in reference to peak and trough amplitudes within the beta band (13 - 30 Hz). This data which reflected the same subject, condition, and electrode site were averaged together and analyzed using a Analysis of Variance (ANOVA) procedure.

Apparatus for Behavioral Data

Behavioral data were collected by instructing subjects to press either a yes or no button as a function of the familiarity of a stimulus on a computer keyboard. A personal computer collected the response time and response accuracy of each stimulus.

Stimuli

Stimuli consisted of 120 words presented in two-second intervals on a standard computer monitor. The stimuli were displaced approximately one degree of visual angle to the left and right of the center screen. Word categories included 30 words relating to the espionage scenario, 30 words relating to the errand scenario, 30 personally familiar words (relating only to the subject's personal preferences and derived from a checklist),

and 30 foil words (words not related to the subject or any scenario). All words were randomly placed in a serial order that remained consistent for every subject. A verbal questionnaire was used to gather familiar words from each subject (see Appendix A). The questionnaire consisted of 30 distinct questions used to gather words personally related to the subject. Individual answers were not allowed to be more than two words in length. If an answer was the same as an item in a scenario or a previous answer, then the subject was asked to give an alternative response.

Procedures

Each subject individually participated in the experiment by enacting a scenario on the first day and then performing a computerized task on the second.

Day 1

The experimental (espionage) group were given a key and told they needed to proceed to another location in a nearby building, enter by the side door, walk down a corridor, locate the correct room, and then enter the room while making sure that no person was in the room prior to entrance. Once in the room, subjects proceeded to a set of locked file drawers said to contain various blueprints of objects (missile diagrams and schematics). They unlocked the file drawer, located and removed any documents or drawings relating to the spacecraft, photographed them with a small pocket camera given to them by the trainer, returned the documents to their correct folders, turned off the lights in the room, and made certain that the door was locked when they left. From that location, they exited the building the same way that they entered. As subjects exited the corridor, they encountered another confederate, posing as one of the janitors, who asked

them casually why they were in the building after-hours. Subjects were coached not to reveal to anyone what they were doing, or where they were going. (Any subjects who did were ejected from the study because they were more likely to have violated other aspects of their instructions as well.) From the building, subjects proceeded to the park located across the street, and waited by the pond for a man wearing a black baseball cap with a soccer ball emblem. They approached the man in the black cap and briefly and quietly made a verbal exchange that indicated their identities. The man then took possession of the camera and gave the subject a sealed envelope containing a note. Subjects then returned to the laboratory for a debriefing with the trainer, producing the note as evidence that they completed the scenario.

The control (errand) group were given a pen, paper sack, and piece of paper, and were told to enter the library using the north entrance. Once in the library, subjects walked to an elevator located in the center of the building and went to the third floor. Subjects then walked out into the third floor and proceeded to find a pre-specified journal and book. Subjects opened the journal and wrote down the title of an article written by a specific author and a specific chapter title to a book. While the subjects were finding the journal and book, they encountered a confederate, who, after making a prespecified verbal exchange, gave each subject a disk which they placed in the paper sack. Once the subjects finished writing down the article and chapter titles on the piece of paper, they placed the pen and paper in the paper sack along with the disk. Subjects exited the library the same way they entered it and stopped to staple the sack twice on their way out. (Any subjects who did not staple the paper sack twice were ejected from the study because they

were more likely to have violated other aspects of their instructions as well.) After leaving the library, subjects proceeded to the clock tower where they approached a man in a blue shirt holding a basketball and briefly and quietly made a verbal exchange that indicated their identities. The man then took possession of the paper sack and gave that subject a backpack. Subjects then returned to the laboratory for a debriefing with the trainer, producing the backpack as evidence that they completed the scenario.

The debriefing for all subjects involved the same individual who initially trained them for the scenario, and covered the main events, i.e., which documents were actually photographed for experimental subjects or which titles were actually written down for Controls. This procedure ensured that the important times, places, people, objects, and sequence of events were experienced by the subject, thereby becoming part of their knowledge base. Subjects were then told that they would be connected to a lie detection device the following day by an examiner who did not know which scenario they had conducted. All subjects were told not to verbally discuss the previously performed scenario with the examiner the following day. The errand subjects were told to be truthful about scenario related information in the experiment the next day, while the espionage subjects were told to conceal information about information related to their scenario.

Day 2

All subjects were fitted with a stretch forming electrode cap. Subjects were then seated in a comfortable recording chair approximately three feet from a 17-inch color monitor attached to the stimulus computer. The stimulus computer was also linked to the

ERP recording system for the purpose of triggering the digitizer. EEG signals were continuously digitized and event triggers were placed on the EEG referenced to stimulus onset. A two-button keyboard was given to subjects who then received instructions to enter manual responses concerning the familiarity of each target stimulus. A stimulus set consisting of 120 single word items was presented, one word at a time, each for a duration of two seconds. Each word was either relevant or irrelevant to the subject's enacted scenario. For instance, the words "key" and "missile" were considered relevant probes for subjects who participated in the espionage scenario while the words "candy" and "towel" were considered irrelevant. The "personally familiar" items were drawn from the questionnaire given the previous day. The items in this category, therefore, were specific knowledge provided by the subject. Subjects were given a practice run on day 1 to insure that they understood what the trial sequence would look like the following day. All subjects received the same sequence of randomized stimuli with their own personally familiar words inserted at the appropriate location in the sequence.

Chapter III

Results

Behavioral Analyses

The behavioral data were analyzed using a 2 X 4 ANOVA design for two groups (experimental, control) and four stimulus categories (espionage, errand, personally familiar, foil) with repeated measures on the latter variable. This model was applied to reaction time as well as response accuracy data.

Results of reaction time data did not reveal any significant main effects. However, a significant interaction effect of group by stimuli was found for reaction time data $F(3,54) = 8.29, p < .001$ with milliseconds being the dependent variable (see figure 2). Post-hoc pair-wise analysis indicated that the experimental group had faster reaction times to all stimulus types ($p < .05$) except for personally familiar items for which no difference between groups was found.

Results for response accuracy data revealed a significant main effect of group $F(1, 18) = 24.47, p < .001$ with average number of correct responses out of 30 being the dependent variable (see figure 3), but not for stimuli. Also, a significant interaction effect of group by stimuli was found $F(3, 54) = 9.07, p < .001$ with average number of correct responses out of 30 being the dependent variable (see figure 4). Post-hoc pair-wise comparisons indicated that the experimental group responded more accurately to all stimulus ($p < .05$) categories except for personally familiar items.

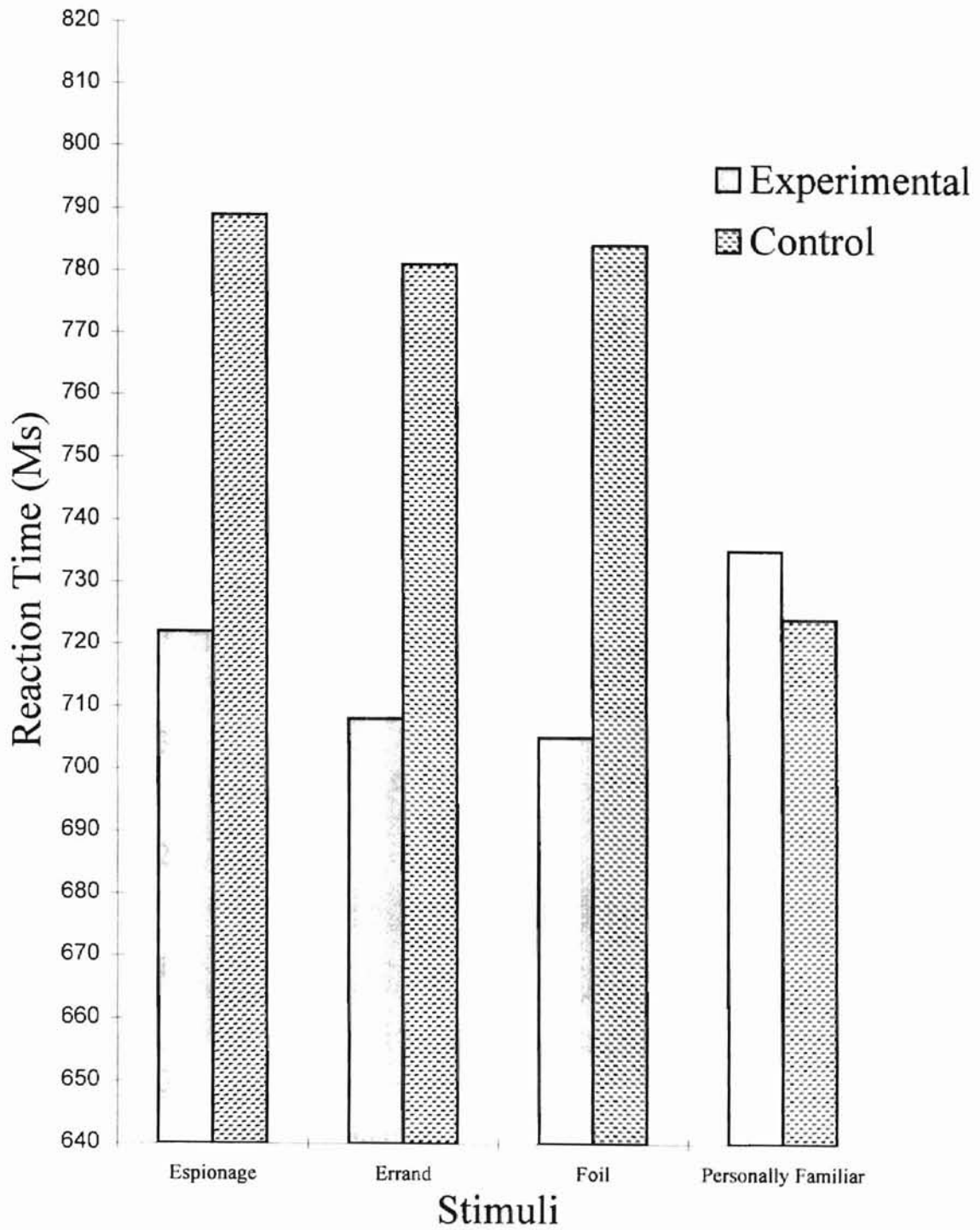


Figure 2. Effect of group by stimuli. Error bars represent one standard error of the mean

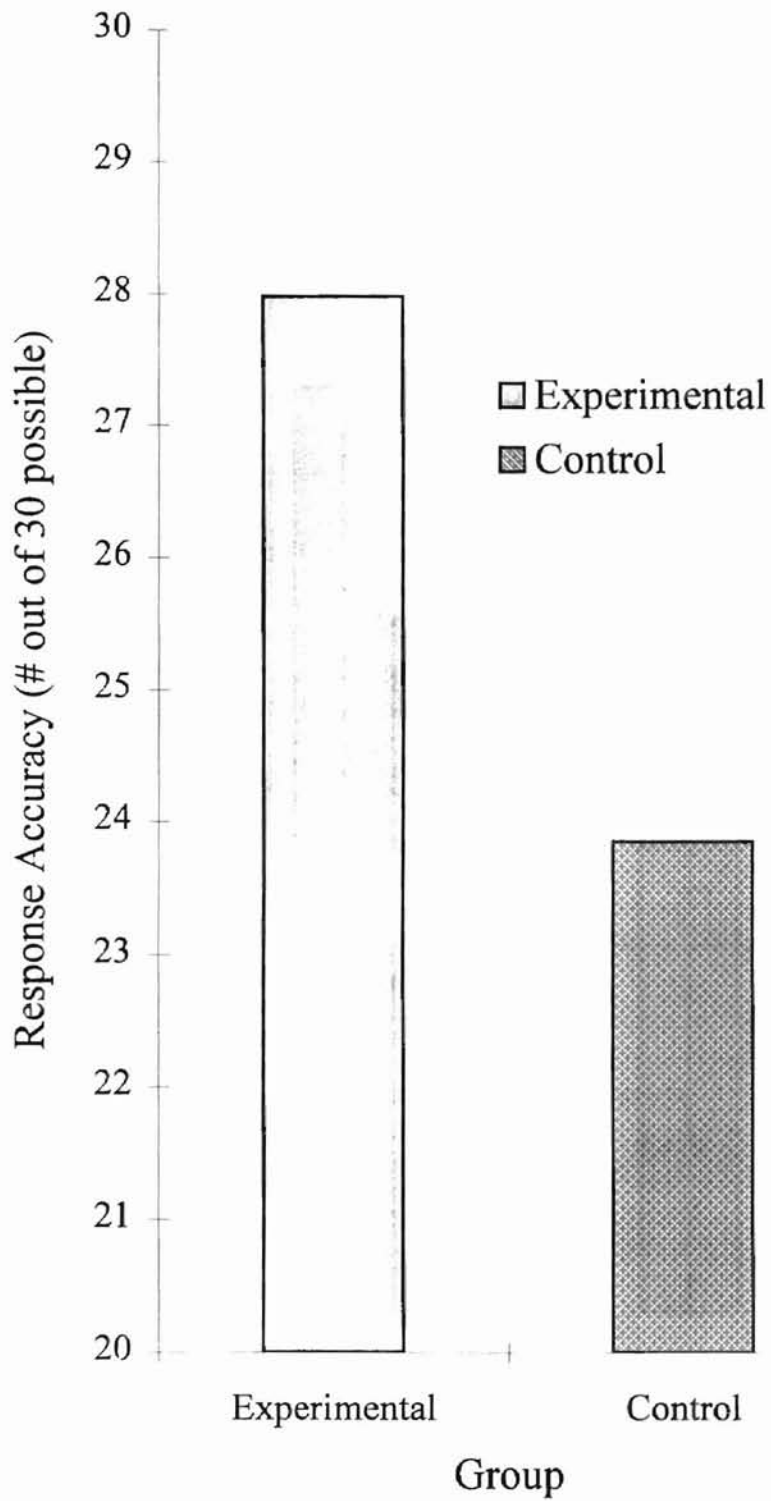


Figure 3. Effect of group on accuracy of response out of a total of 30 trials per trial type condition. Error bars represent one standard error of the mean.

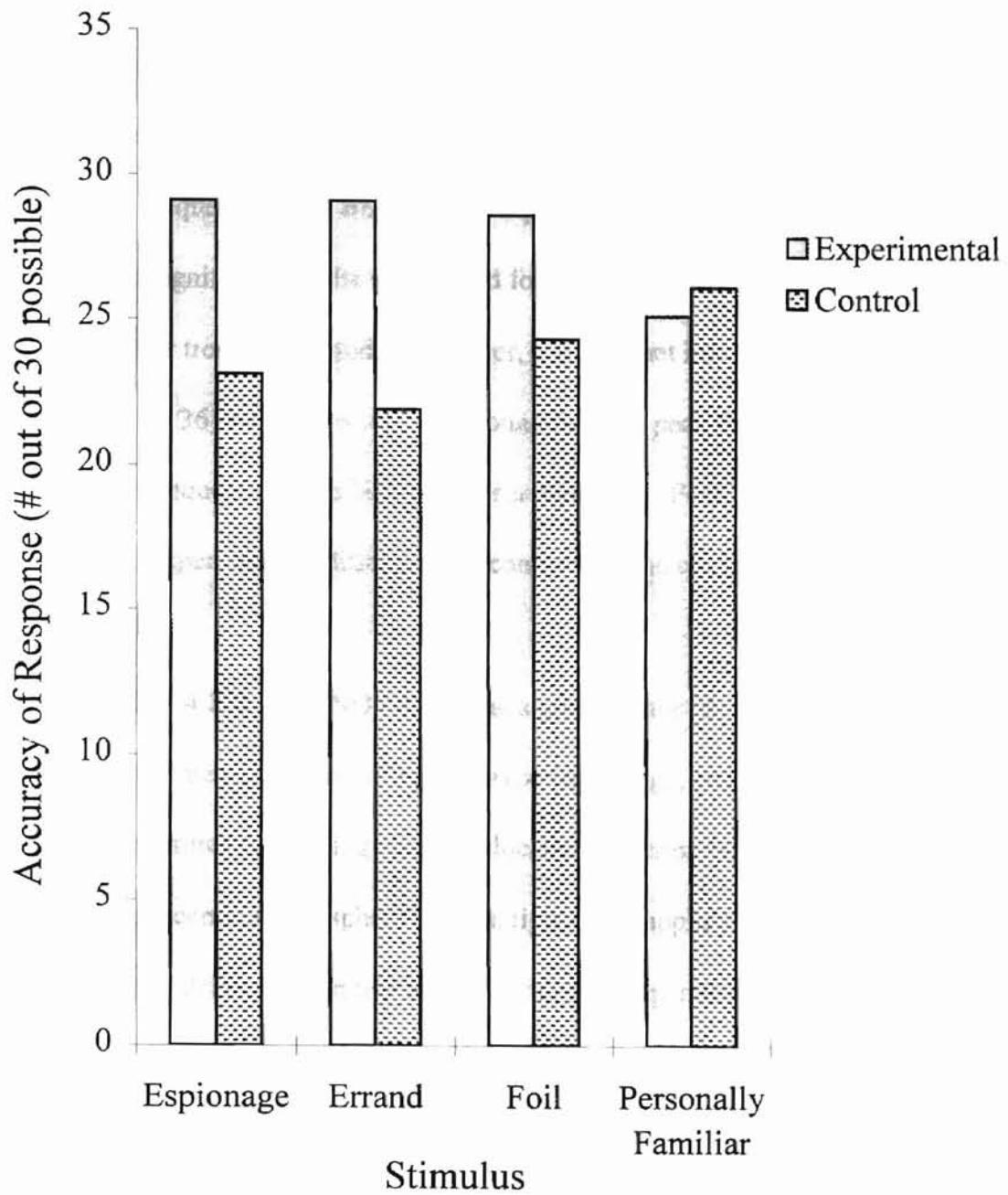


Figure 4. Effect of group by stimuli on accuracy of response.
 Error bars represent one standard error of the mean.

Spectral EEG Analyses

A 2 X 4 X 3 ANOVA, having a group factor (deceptive versus nondeceptive), four repeated measures concerning stimuli (espionage, errand, personally familiar, foil), and three repeated measures for electrode location (Fz, Cz, Pz) was applied to the midline spectral EEG data. This model was separately applied to four dependent variables: high peak frequency, peak amplitude, low peak frequency, and trough amplitude.

No significant results were found for peak amplitude, low peak (trough) frequency, or trough amplitude. However, a significant interaction effect of group by midline $F(2, 36) = 5.69, p < .007$ was found for high peak frequency data with a metric of average frequency of the high peaks (see figure 5). Post-hoc pair-wise comparisons found that Experimentals differed from controls for the electrode sites Fz and Pz but not at Cz.

A 2 X 4 X 2 X 2 ANOVA, having a group factor (deceptive vs. nondeceptive), four repeated measures concerning trial-type (espionage, errand, personally familiar, foil), repeated measures concerning electrode location (anterior vs. posterior), and repeated measures concerning hemisphere (left vs. right), was applied to the sagittal spectral EEG data. This model was separately applied to all four dependent variables: high peak frequency, peak amplitude, low peak frequency, and trough amplitude.

No significant main effects were found with high peak frequency data and peak amplitude data. However, a significant interaction of electrode by hemisphere $F(1, 18) = 4.28, p = .053$ was found with respect to peak amplitude (see figure 6). The left

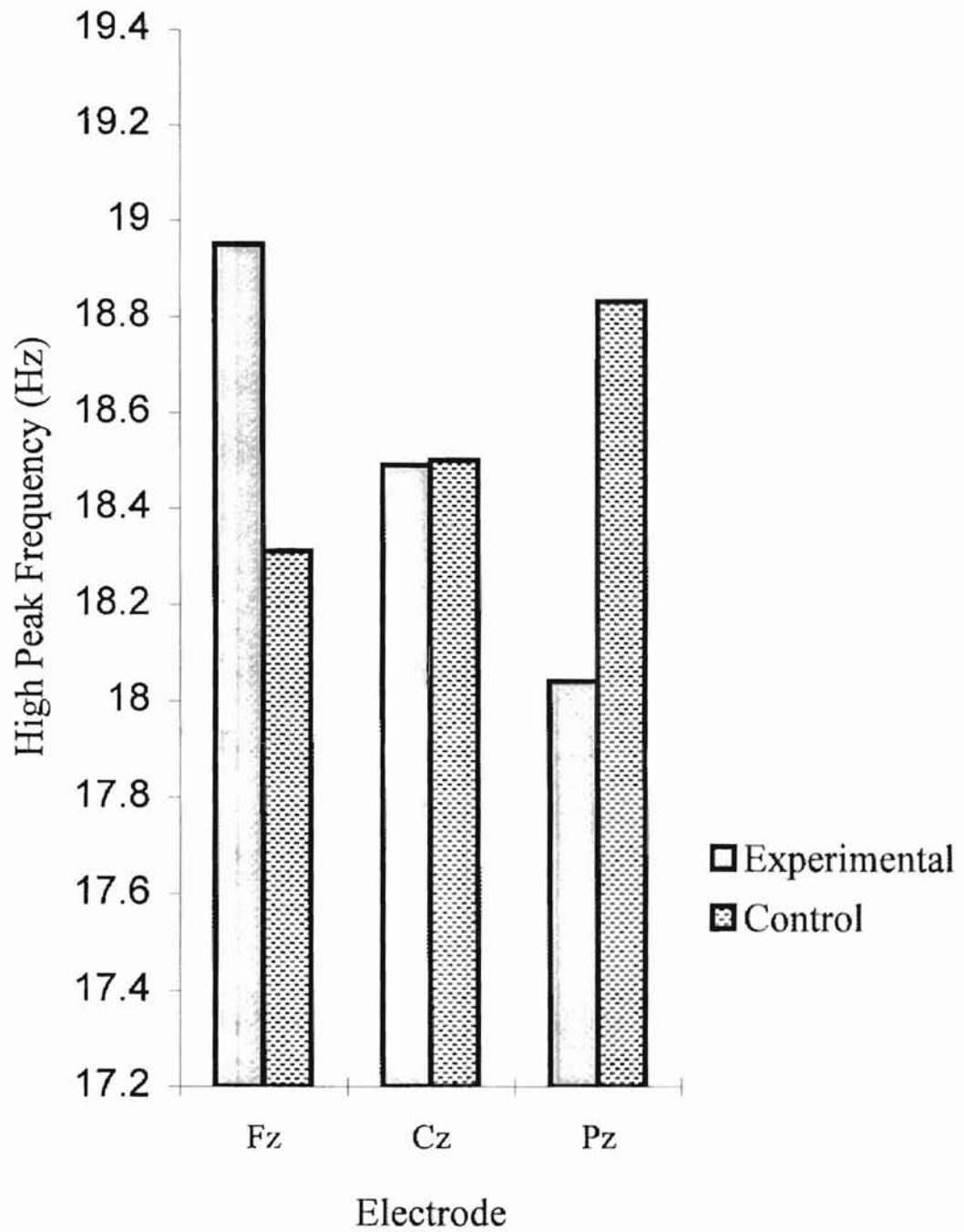


Figure 5. Effect of group by midline sites for high peak frequency.
Error bars represent one standard error of the mean.

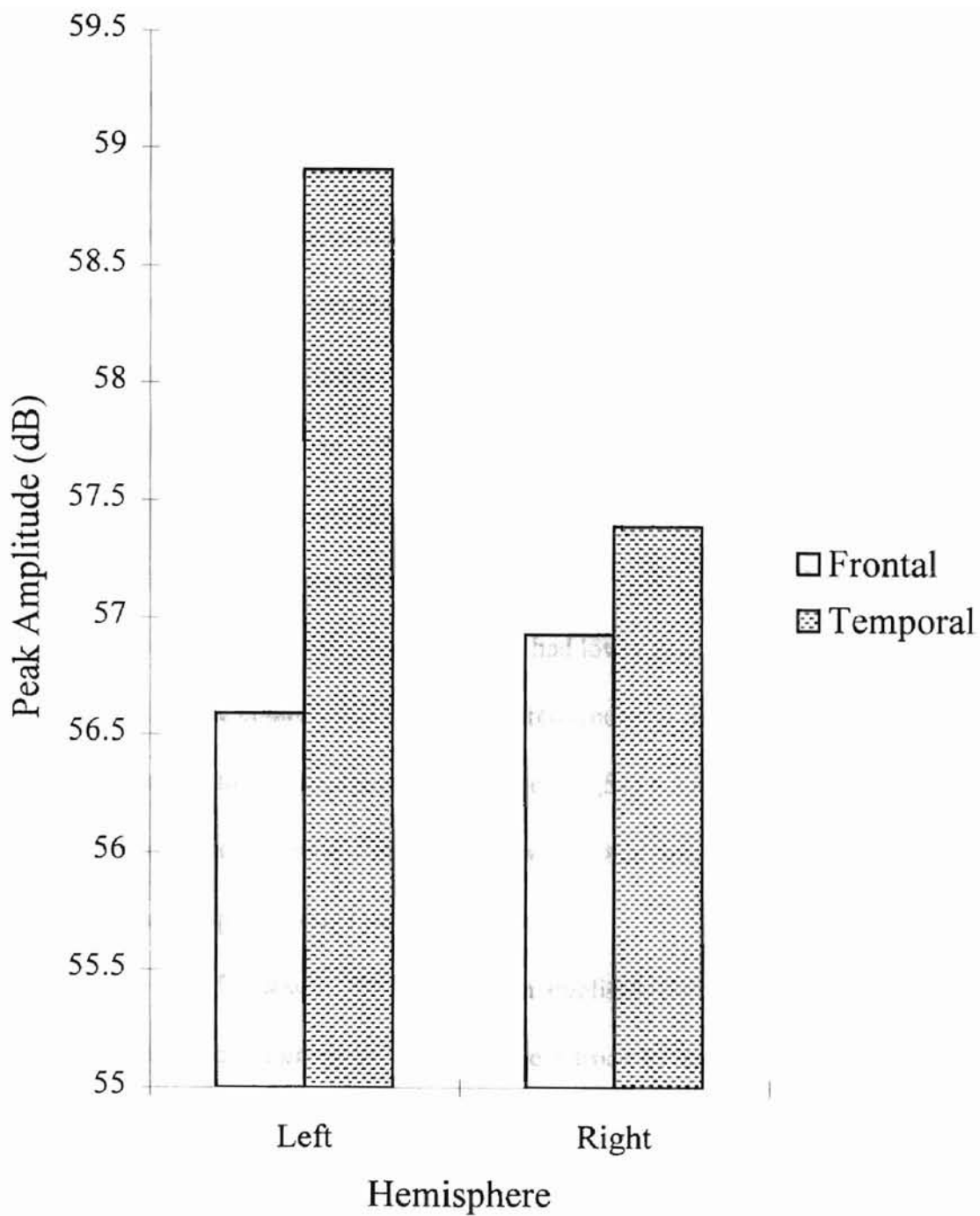


Figure 6. Effect of electrode by hemisphere for sagittal peak amplitude data. Error bars represent one standard error of the mean.

hemisphere temporal site had a higher peak amplitude than the left hemisphere frontal site.

No significant main effects were found for low peak frequency data. However, several significant interaction effects were found. A significant three-way interaction of group by stimulus by hemisphere $F(3,54) = 2.99, p < .04$ was found (see figure 7). Post-hoc analysis found that experimental subjects differed from control subjects on personally familiar items in the right hemisphere and with errand words in the left hemisphere. Control subjects had frequency troughs at a higher frequency than experimental subjects for both familiar items in the right hemisphere and errand words in the left hemisphere. A significant interaction of group by electrode $F(1,18) = 14.48, p < .001$ was also found for low peak frequency data (see figure 8). Experimental subjects had lower peak frequencies at temporal sites than controls while controls had lower peak frequencies at frontal sites. Last, a significant interaction of stimulus by electrode $F(3,54) = 3.43, p < .023$ was found (see figure 9). Post-hoc pair-wise comparisons revealed that only errand stimuli differed in frontal versus temporal trough peak frequency.

No main effects were found for trough amplitude data. However, a significant four-way interaction of group by stimulus by electrode by hemisphere $F(3,54) = 4.04, p < .02$ was found (see figure 10). Post-hoc pair-wise comparisons revealed that Experimental subjects differed from controls ($p < .05$) on espionage words at T3, errand words at T3, foil words at F7, T3, and T4, and with personally familiar words at T4. Given that four-way interactions are exceedingly complex and prone to spurious effects, this result

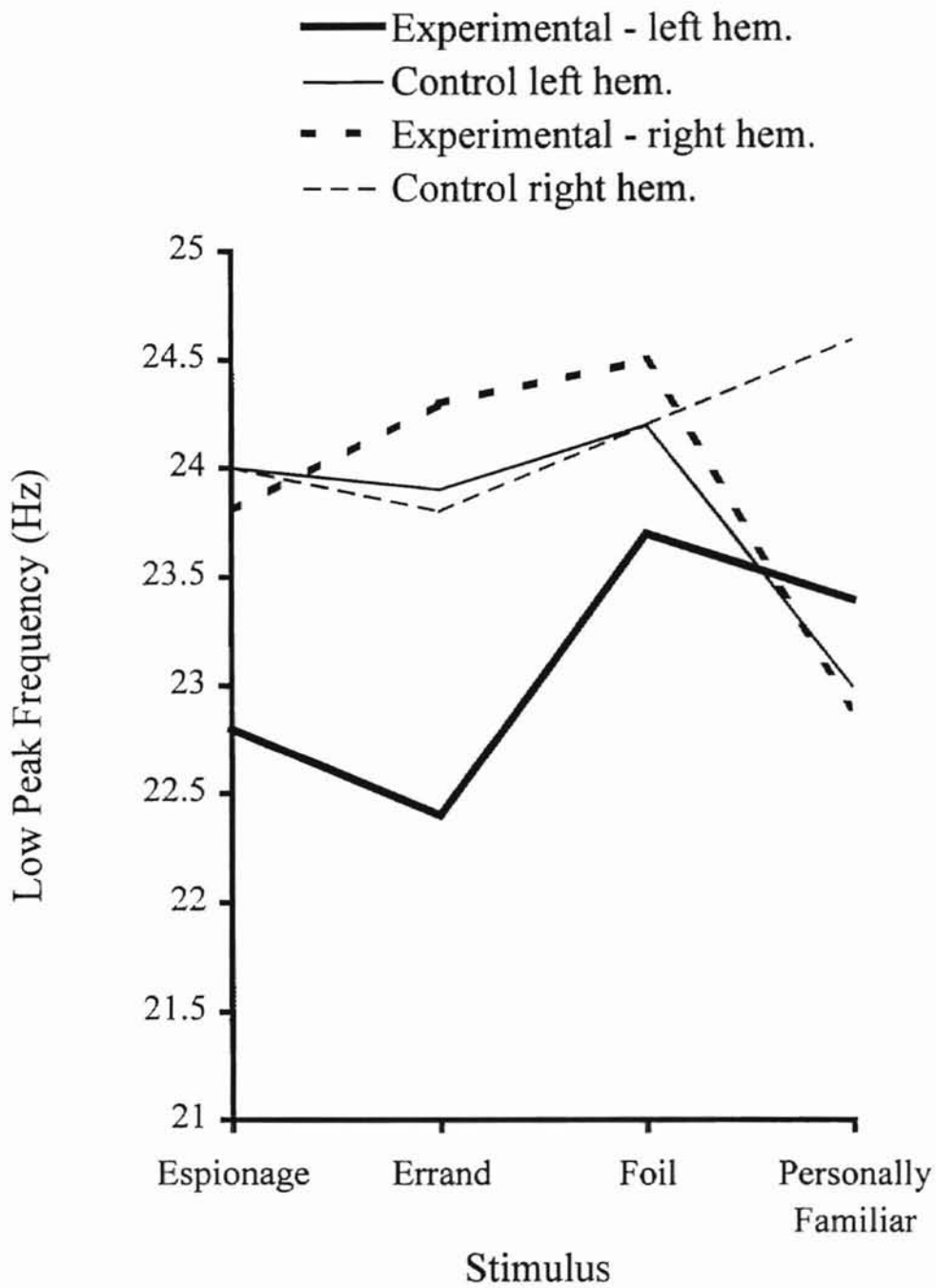


Figure 7. Effect of group by stimulus by hemisphere for low peak frequency data.

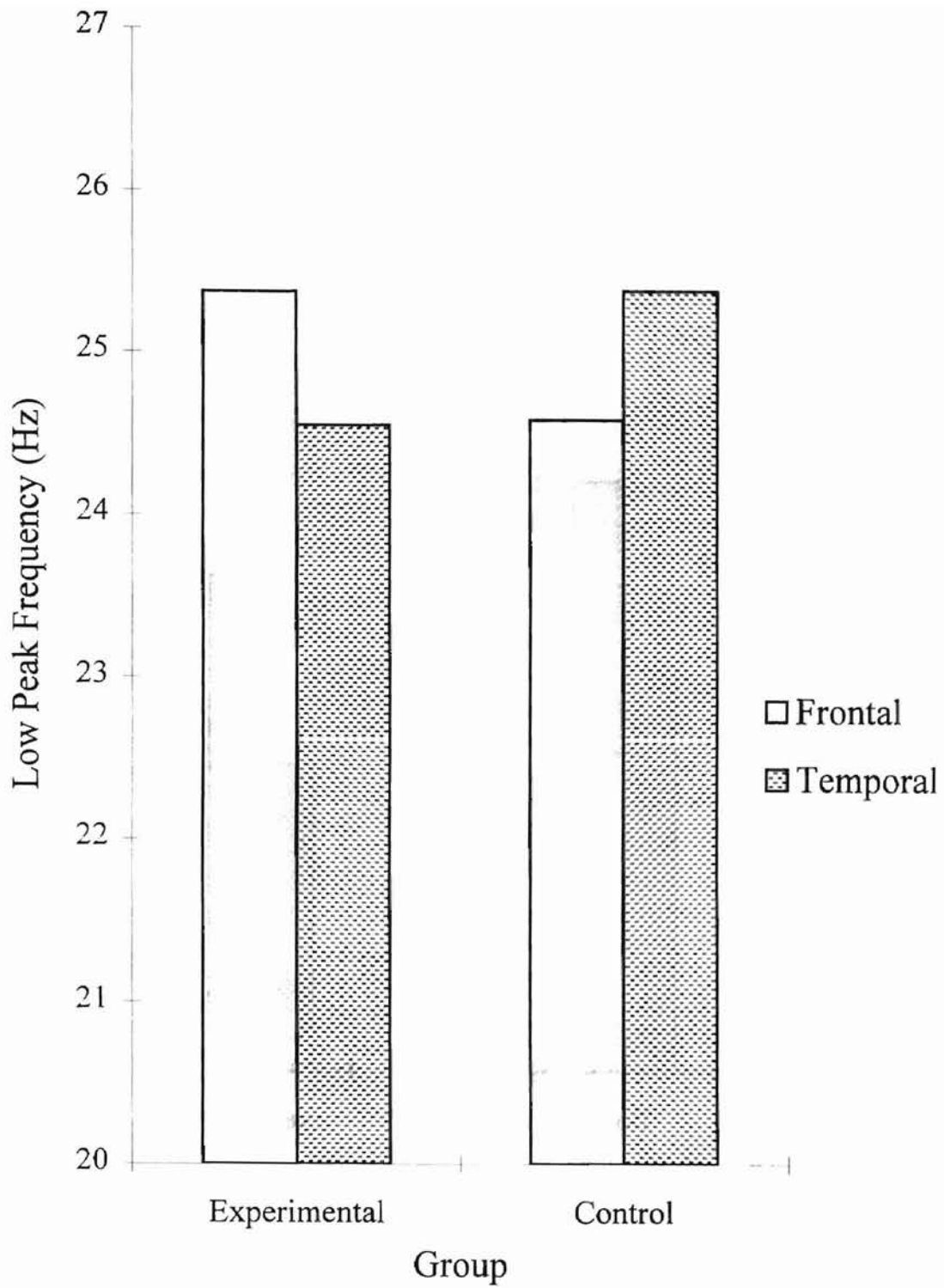


Figure 8. Effect of group by electrode on sagittal low peak frequency data. Error bars represent one standard error of the mean.

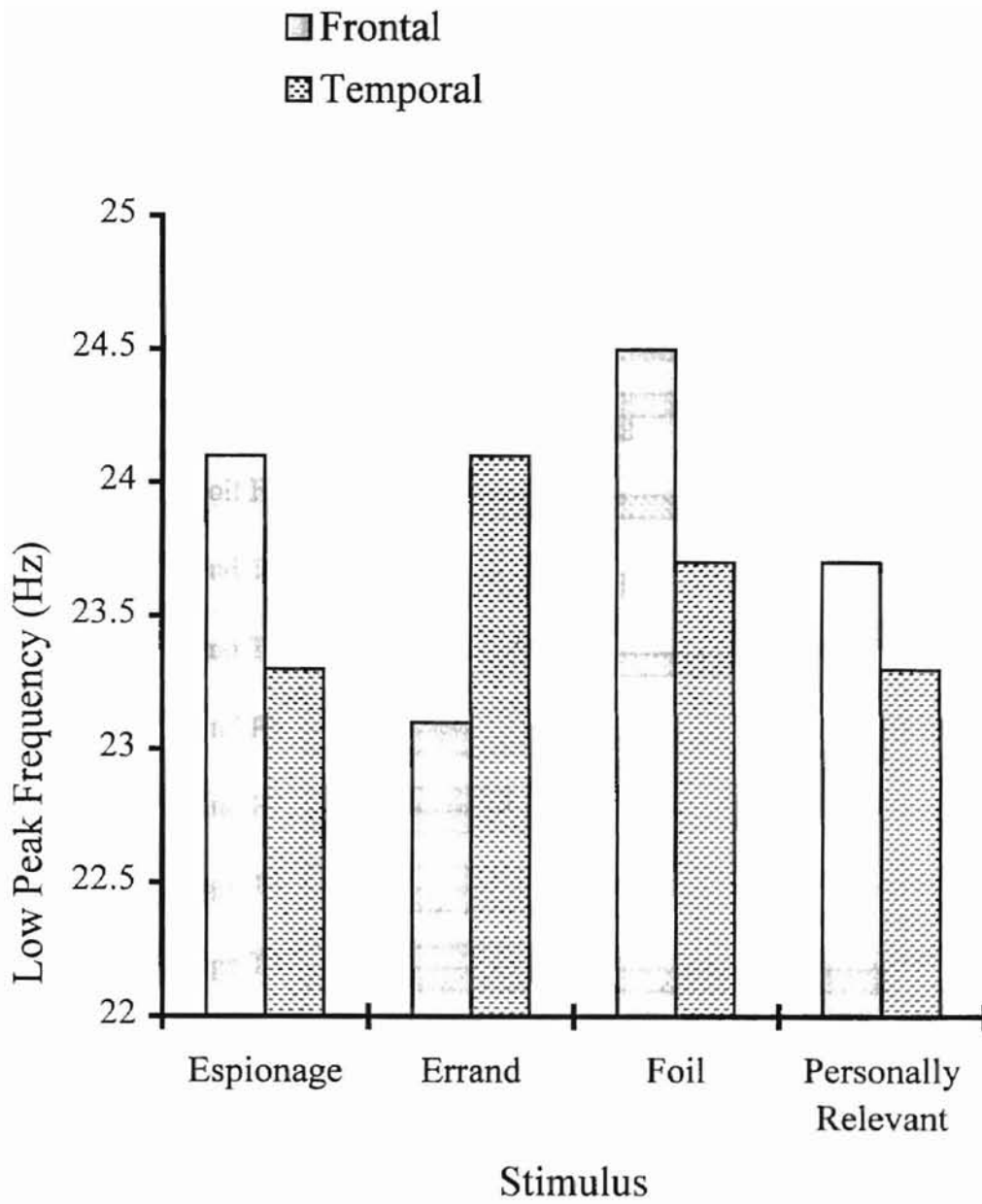


Figure 9. Effect of stimulus by electrode on low peak frequency data. Error bars represent one standard error of the mean.

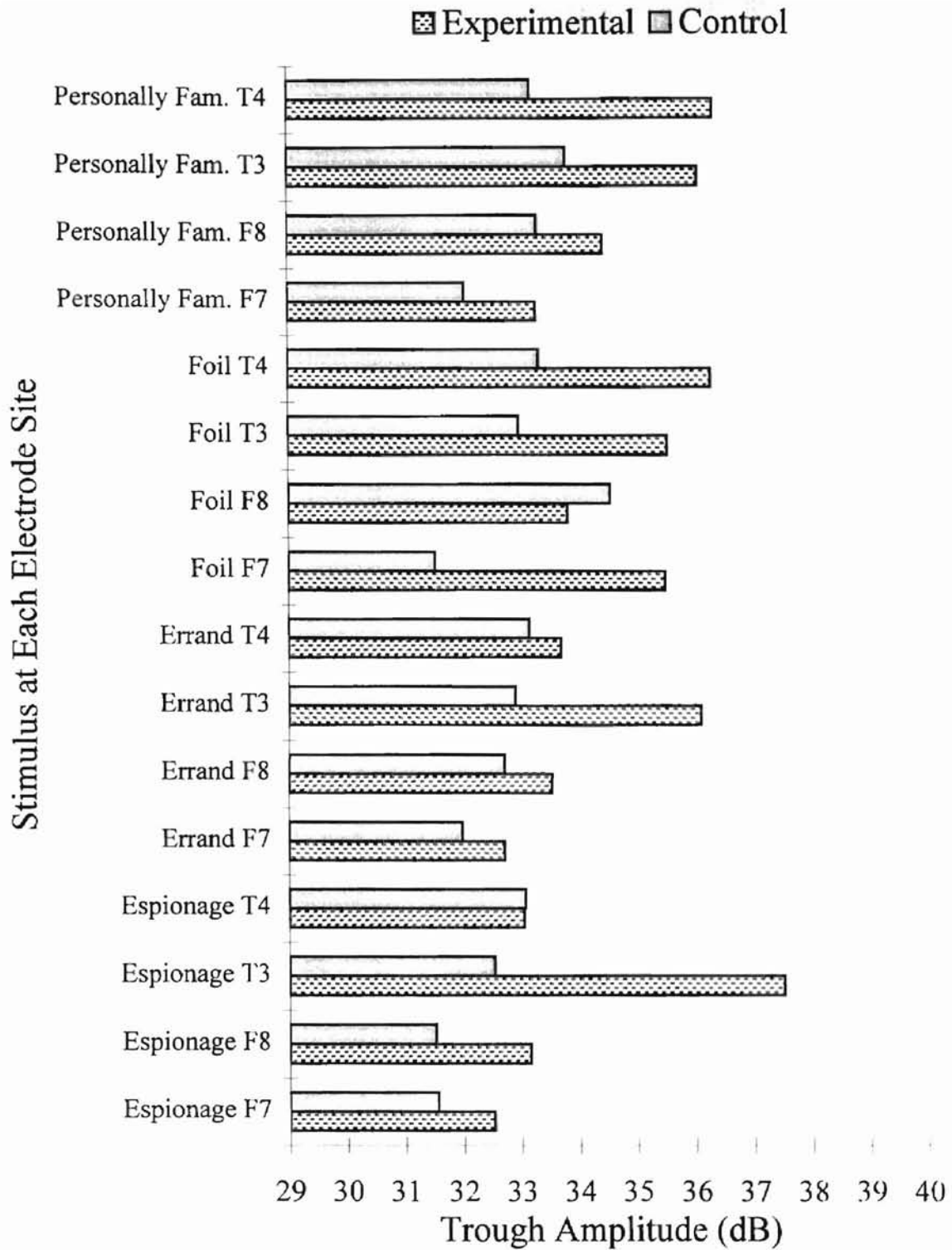


Figure 10. Effect of group by stimulus by electrode by hemisphere. Error bars represent one standard error from the mean.

will not be interpreted or discussed with the same degree of sensitivity as lower order interactions.

Chapter IV

Discussion

Results of this study reveal that both behavioral and spectral differences between deceptive and non-deceptive subjects exist. Deceptive subjects process stimuli differently from non-deceptive subjects. However, this difference does not appear to be a function of relevance of, or familiarity with, a stimulus. Instead, group differences occurred with respect to whether the subject was directed to lie or not. This is consistent with behavioral findings in Locker and Pratarelli (1997) in which experimental subjects performed differently than control subjects or informed subjects in all stimulus type conditions. In their experiment, however, Experimentals were slower in all conditions than Controls.

Behavioral Findings

In contrast to Locker and Pratarelli (1997), deceptive subjects in the present experiment were faster and more accurate than nondeceptive subjects at responding to all stimuli except for personally familiar words (Figure 2). The results indicated that the difference on response accuracy, however, can be explained as a main effect of group. Previous research has often found a trade-off between response time and response accuracy (cf., Dickman & Meyer, 1988; Locker & Pratarelli, 1997). Subjects who respond slower tend to be more accurate, and vice-versa, because being more accurate requires more controlled effort. This controlled effort requires more cognitive processing revealed by slower reaction times (Kihlstrom, 1987). Locker and Pratarelli (1997) found that deceptive subjects responded slower than non-deceptive subjects because the act of

concealing information required more conscious and controlled effort than nonconcealment. The present results are consistent with these findings in that differences were found between deceptive and nondeceptive subjects. However, the present findings differ in that deceptive subjects were faster and more accurate in responding to stimuli. This departure from previous findings may be due in part to (1) motivation, and (2) to subtle differences in task demands.

Motivation may cause experimental subjects in the present study to respond quicker and more accurately to all stimuli except for personally familiar items. The supposition that motivation differentially affects deceptive versus non-deceptive subjects may center on the notion that deceiving with impunity is intrinsically enjoyable. Moreover, all subjects were motivated to participate in the present experiment by being offered extra-course credit for each hour of participation and by the nature of the study. The underlying logic is that deceptive subjects may have greater motivation or self-investment in the act of potentially deceiving the examiner while the non-deceptive subjects had little or none at all. Previous studies that have examined deceit have tried to equate motivational levels of deceptive and non-deceptive subjects either by offering specific incentives for performance, such as monetary rewards, or by utilizing a design that allows subjects to choose whether to be deceptive or nondeceptive (Elaad & Ben-Shakhar, 1989; Furedy & Ben-Shakhar, 1991; Locker & Pratarelli, 1997). The use of monetary rewards assumes that motivation derived will overcome intrinsic motivation, and thus equate deceptive and non-deceptive subjects. Alternatively, the use of a design that allows subjects to choose whether to deceive or not assumes that all subjects will be

equally intrinsically motivated because each participant would receive some degree of self gratification and self-efficacy from the choice made (Bandura, 1977). However, these two approaches used to control for motivation may lack ecological validity because consequences often seen when an individual submits to a lie-detection test are absent. Nonetheless, future research needs to clarify whether the current behavioral results reflect differences in intrinsic motivation, and whether that motivation equates with that seen in genuine deception.

In terms of task demands, another reason the present deceptive subjects performed, as a group, similar to Locker and Pratarelli's (1997) subjects, but faster instead of slower, is less ecological validity. In Locker and Pratarelli, when subjects self selected into the deception group they believed they were both fooling the investigator, and their integrity would be questioned if they were discovered, i.e., it was learned that they had taken a list of words to be presented on the next day's test from a confederate. From these subjects' perspective, their self-efficacy was principally determined by their investment in not disclosing that they had taken a single piece of paper for their own personal gain. In the present study, this personal self-investment and loss of integrity through discovery is significantly diminished because (1) subjects worked together with their trainer to fool the examiner, and (2) there was no potential loss of integrity if their deception was discovered because they were told to do so in the context of the experiment. That is, the deception had been, in effect, legitimized and operationalized in the task demands. Thus, Locker and Pratarelli's subjects would have had to slow down to

increase their accuracy in order to maintain their deception while the present subjects could afford to speed up.

An alternative explanation for the behavioral findings is that experimenter bias caused deceptive subjects to respond differently to stimuli than non-deceptive subjects. This explanation also might explain why personally familiar words were not different for either group. However, the close scrutiny in controlling all aspects of the experiment in order to keep both groups consistent with regard to potential confounds may invalidate this explanation. For instance, the same trainer and Day 2 experimenter were used for all subjects. Also, confederates memorized their corresponding verbal exchange and the scenarios were set up in such a way to only allow for specific oral statements. Finally, both the trainer and the Day 2 experimenter had specific scripts to follow in order to insure that each subject was treated consistently. Thus, excessive attention to consistency during data collection makes the argument for experimenter bias weak at best.

The finding that group differences occurred for all stimulus types except personally familiar words might be better explained in that personally familiar words are self generated while the other stimulus types were not. Recall that personally familiar words were gathered from each subjects' prior experiences independent of the experiment. But, the relevant scenario items were experienced by subjects only within the confines of the experiment. Thus, self generated items may include *ego involvement* where the other stimuli did not (M. E. Pratarelli & D. Krapohl, personal communication, April 16, 1999). In this sense, ego involvement is a psychological construct that is implicitly related to one's sense of self, efficacy, and personal investment (Bandura,

1977). Bandura and others (e.g., Pratarelli & McIntyre, 1994) have shown that as the subject's sense of personal investment and ego involvement increased, so did their individual or group performance. Note, however, that the use of the term "ego" is here, a matter of convenience, rather than an endorsement or inclusion of the various definitions and issues raised by Freud's psychodynamic theory. Personally familiar words may not have differentiated deceptive from nondeceptive subjects because both groups had equal ego involvement whereas the other stimulus types are not affected by this construct.

Spectral Findings

The finding that deceptive subjects process stimuli different from nondeceptive subjects is shown by the midline effect of group by electrode for high peak frequency data, illustrated in Figure 5. This effect is interesting in that high peak frequency may index the level of Beta activity in anterior versus posterior regions of the brain. Recall that Beta activity reflects more processing of the cognitive variety. Generally, it is axiomatic in neuroscience that the posterior portion of the cortex is dedicated to sensory and perceptual processing of stimuli from the environment, while the anterior portion is dedicated to the organism's motor behavior, thought, and responses to the environment. The act of deception recruits all three of the latter processes. Thus, the main effect of group is interesting in that the deceptive subjects showed a higher peak frequency in the Beta bandwidth at Fz, an anterior site, than nondeceptive subjects, while the opposite occurred at Pz, a posterior site.

Using the explanation discussed earlier regarding personal investment, integrity, self-efficacy, and ecological validity as construed in the term "ego involvement",

deception may be indexed by cortical activation in frontal brain areas that would be concerned with such matters of the self. While this is merely drawing the causal argument from the observed correspondence between frontal EEG activity and the inferred location of the cortical substrates for “ego”, self, or thought in general, it raises an important testable hypothesis for future research to address. In support of this argument, it is important to note that the preponderance of brain-imaging research, clinical neuropsychological evidence, and research in the psychopathology of Schizophrenic and affective disorders have localized thought-related brain electrical activity to the frontal lobes (Gershon & Rieder, 1993).

A similar effect of anterior to posterior processing in lateral sites is seen with the effect of group by electrode with low peak frequency data. As in high peak frequency, low peak frequency may similarly index deception. In addition, it is important to note that if peak-to-peak amplitude at each frequency band had been calculated and used as a dependent variable, it would have been equally sensitive to deception. Although not always used, peak-to-peak power or voltage has been a dependent variable in previous research.

Subjects did not process stimuli differently based on relevance of the stimulus. If relevance to scenarios were to differentiate deceptive from non-deceptive subjects, then group differences would be expected for stimuli that are relevant for one group but not the other, i.e., espionage vs. errand. The three-way interaction of group by stimulus by hemisphere for low peak frequency data indicates that group differences exist for errand words in the left hemisphere, but no differences were found for errand words in the right

hemisphere (Figure 7). There were no differences for espionage words in either hemisphere. Thus, relevance to scenario was not found in those two conditions for either group of subjects.

Group differences do not appear to be a function of the familiarity of the stimulus. The effect of group by stimulus by hemisphere for low peak frequency data reveals that deceptives differed from nondeceptives on personally familiar words in the right hemisphere. However, these results do not correspond to the familiarity of a stimulus because both deceptives and nondeceptives were similarly familiar with personally familiar items and nonfamiliar with foil items and irrelevant items from the scenario they did not participate in. Nonetheless, the observed difference between groups on personally familiar items is not readily interpretable, and in fact, is contrary to what was predicted on theory alone; it awaits further study.

The last major finding is that certain individual electrode sites distinguish between deceptive and nondeceptive subjects. The sagittal effect of group by stimulus by electrode by hemisphere for trough amplitude data shows that deceptive subjects have higher trough amplitudes with espionage and errand words at T3, foils at F7, T3, and T4, and with personally familiar words at T4 (Figure 10). Again, these findings can not be attributed to the familiarity of the stimulus because deceptive subjects have higher scores whether the stimulus was familiar or unfamiliar. The espionage and errand stimuli differences found at site T3 are interesting in that they may index group differences in processing of scenario items. This interpretation is reasonable because T3's placement is in close proximity if not directly over Wernicke's area which is involved in word

comprehension (Harley, 1995). Thus, group differences in T3 processing seem to be related to the context of the scenario. However, the group differences found for foil and personally familiar stimuli again lack a reasonable explanation because both groups responded similarly to both stimulus types. The only interpretation that might explain this finding is that deceptive subjects generally process all stimulus types differently from nondeceptive subjects. However, such an interpretation is highly speculative. Locker and Pratarelli (1997) have argued that one potential explanation for additive effects on behavioral measures like reaction time and response accuracy may concern a post word recognition decision or response stage delay attributable to individuals who are aware they intend to deceive and must guard against being detected.

Several significant spectral EEG findings were found that are unrelated to any hypotheses of this study. The effect of electrode by hemisphere for peak amplitude data where the left temporal site showed a higher peak amplitude than the left frontal site is not clearly interpretable. However, this effect could be due to differences in language processing because the temporal site may better index language processing than the frontal site. An interpretation of the effect of stimulus by electrode for trough peak frequency is also unclear. No logical reason why only errand stimuli would differ in relation to frontal versus temporal sites has been determined. In lieu of an explanation, this finding might be reconciled as a Type I error.

Implications & Future Research

Behaviorally, intrinsic motivation appears to account for the differences between groups, i.e., between deceptive and nondeceptive subjects. However, this interpretation

does not explain why group differences were not found for personally familiar words in both reaction time and response accuracy. Future research should examine motivational attributes of deception more closely in order to determine the extent to which behavioral indices can discriminate between deceptive and nondeceptive subjects. Since deception is a predominantly conscious process, deceptive subjects may require more controlled cognitive processing in order to intentionally respond falsely to stimuli (Locker & Pratarelli, 1997). However, if motivation alone can account for differences between behavioral measures, then this finding may also reveal just how easily such indices can be consciously controlled. A concern in lie-detection is whether an individual could potentially 'beat' the examiner using a consciously controlled state of mind (Bashore & Rapp, 1993). If intrinsic motivation can indeed account for differences between deceptive and nondeceptive subjects, then the extent to which behavioral data can accurately predict whether the subject is indeed guilty or innocent of deceiving is questionable because of the ease with which subjects can consciously control such behaviors.

It is important to note a dearth of research concerning intrinsic motivation and its effects on deception. It does not facilitate exploring the implications of the behavioral findings. Intrinsic motivation has been found to be a function of many cognitive constructs (i.e., interest, effort, excitement, arousal, intention, etc.) all of which are related to individual differences. As a minimum, future research should include a survey given to subjects at the end of the experiment to determine whether motivation is a function of deception or individual differences.

Although the behavioral results might be related to intrinsic motivation, the spectral EEG results are less likely to be a function of motivation because Beta frequencies reflect higher cognitive processing (Andreassi, 1989). However, Alpha and Delta activity that reflect relaxation and underarousal respectively may indicate whether motivational differences exist because attention is often seen behaviorally as alertness as in intentional learning (Kosslyn & Koenig, 1992). Thus, future research should examine these frequency bands as possible indices of motivational differences.

The most intriguing finding at present is the spectral difference found between deceptive and non-deceptive subjects that appear to be a function of perceptual versus response processing. This finding is important because it differs from differences found in previous deception research. PDD, in examining deceptive versus nondeceptive SANS activity, has not found a direct index of deception (Ford, 1995). Previous research utilizing EEGs have the theoretical advantage of measuring deception more accurately because they index the CNS, but have only been able to discriminate between deceptive and nondeceptive subjects based on word familiarity or context violation. However, the current findings not only measure CNS activity, but they are also not a function of the relevance or familiarity of stimuli. Although the familiarity of stimuli has been found to be a reliable indicator of deception, often unavailable details of the act in question are required to utilize this technique (i.e., the GKT vis a vis Farwell & Donchin, 1991; Rosenfeld et al., 1988). However, group differences found between anterior and posterior regions of the brain may be a more valid and reliable measure of deceit because these effects occurred irrespective of stimulus type. Thus, this finding may be a tenuous

indicator of concealed information that has previously eluded lie-detection researchers. Replications need to be conducted to insure that deceptive and nondeceptive subjects do in fact differ in respect to anterior-posterior processing. Second, statistical discrimination techniques should be employed to determine whether this difference can differentiate deceptive from nondeceptive subjects on an individual basis. Third, future research needs to examine whether this measure is sensitive to a conscious attempt to trick the examiner as in the use of physical and mental countermeasures.

The finding that site T3 distinguishes between espionage and errand stimuli is interesting because it may reflect the processing at Wernicke's and surrounding areas. However, the inability to interpret why group differences exist between foil and personally familiar items in relation to particular sites leaves one to wonder if such group differences are more a function of the sensitivity of spectral EEG to spurious effects. Nonetheless, these sites do differentiate deceptive from nondeceptive subjects and future research should examine them more closely in order to determine why they, and not others, are sensitive to group differences.

Although the implications of these results have been directed toward distinguishing deceit from nondeceit, they provide several insights into the conceptual understanding of deception. Specifically, deception seems to differ from nondeception in relation to anterior versus posterior processing. However, specific interpretations concerning spatial differences are premature because many techniques such as topographic measures of cortical activity provide better spatial resolution than spectral EEG. Thus, future research using tools that are more spatially detailed such as

computerized topography, functional magnetic resonance imaging, and positron emission tomography should be conducted to explain more precisely where deceptive processing differs from nondeceptive processing. The anterior-posterior differentiation may give comparative clues as to how deception evolved. Researchers have increasingly used the act of deception as an indicator of complex mental processing when comparing humans to other primates (Greenberg, 1999). If deception does require the development of increased mental processing, then the ability to skillfully deceive may correspond to the enlargement of the frontal lobes, where conscious thought processes may occur (Fischbach, 1992). A comparative approach to the development of deceptive behaviors may be studied by examining differing types of deceptive behaviors in relation to anterior-posterior processing. For example, deceptive behaviors range from simple acts, like withholding information, to complex behaviors, like purposefully misleading another person. Future research should examine whether complexity of deceptive behaviors corresponds to differences found between anterior and posterior development, specifically the development of the frontal lobes.

Conclusions

This study has provided electrophysiological as well as behavioral evidence that deceit can be detected using CNS measures of cognitive processing. More importantly, the evidence suggests that the anterior versus posterior regions of the cortex process deception and nondeception differentially. The findings are preliminary due to the exploratory nature of the study. Nonetheless, these findings suggest that spectral EEG

can be used to further the understanding of lie detection, the nature of deception, and ultimately guilt.

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Appendix A

Verbal Questionnaire Related to Personally Familiar Words

Order	Question	Answer
1	Mother's first name	_____
2	Favorite color	_____
3	Type of vehicle you drive the most	_____
4	Favorite meal (breakfast, lunch, dinner)	_____
5	Favorite season	_____
6	Favorite food	_____
7	Favorite fruit	_____
8	Month born	_____
9	Favorite sibling or friend	_____
10	Favorite type of pet	_____
11	Name of the street that you live on	_____
12	Favorite type of drink	_____
13	Favorite type of music	_____
14	Favorite language	_____
15	Favorite number between zero and nine	_____
16	Favorite Sport	_____
17	Favorite Furniture	_____
18	Favorite smell	_____
19	Favorite mode of travel	_____
20	Favorite type of bread	_____
21	Favorite recreational/hobby activity	_____
22	Favorite time of day	_____
23	Favorite cloth	_____
24	Favorite type of game (board, cards)	_____
25	Favorite climate	_____
26	Favorite type of terrain	_____
27	Favorite type of place to visit	_____
28	Most positive part of your personality	_____
29	Type of person that you would like to be	_____
30	Type of career that you want to strive for	_____

Appendix B

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 07-23-97

IRB#: AS-98-001

Proposal Title: ERPS AND THE DETECTION OF CONCEALED INFORMATION

Principal Investigator(s): Marc Pratarelli, Adam Lawson

Reviewed and Processed as: Expedited

Approval Status Recommended by Reviewer(s): Approved

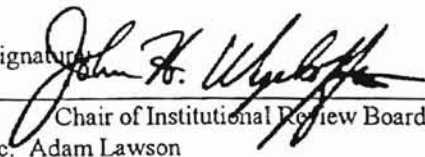
ALL APPROVALS MAY BE SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING, AS WELL AS ARE SUBJECT TO MONITORING AT ANY TIME DURING THE APPROVAL PERIOD.

APPROVAL STATUS PERIOD VALID FOR DATA COLLECTION FOR A ONE CALENDAR YEAR PERIOD AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.

ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Disapproval are as follows:

Signature


Chair of Institutional Review Board
cc. Adam Lawson

Date: August 7, 1997

VITA

Adam Lee Lawson

Candidate for the Degree of

Master of Science

Thesis: RECOGNITION OF CONCEALED INFORMATION WITH BEHAVIORAL AND SPECTRAL ANALYSES

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