To the Graduate Council:

I am submitting herewith a dissertation written by Steven J. Cloud entitled "Auditory Evoked Potentials for Words with High Positive and High Negative Connotative Values." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Speech and Hearing Science.

Harold A. Peterson, Major Professor

We have read this dissertation
and recommend its acceptance:

Accepted for the Council:

Associate Vice Chancellor and
Dean of The Graduate School

AUDITORY EVOKED POTENTIALS FOR WORDS WITH HIGH POSITIVE AND HIGH NEGATIVE CONNOTATIVE VALUES

A Dissertation
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Degree
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Steven J. Cloud
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DEDICATION

This dissertation is dedicated to my wife

Mrs. Mary Margaret (Meg) Cloud

to my son

Cameron Alexander Cloud

and to my parents

Mr. and Mrs. Lewis Edward Cloud

who have given me the invaluable support and love

needed to complete the doctoral requirements.

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ABSTRACT

This study was conducted to determine whether word connotations (or the "meaningfulness" of words) can be discriminated with Auditory Evoked Potentials (AEPs). The Semantic Differential Scale was used to obtain a list of 10 one-syllable words with high positive valences (i.e., "peace," "bride"), and 10 one-syllable words with high negative valences (i.e., "rape," "beat"). Fifteen female graduate students listened to 80 stimulus words, and they pushed one button if the word was "positive" and another if the word was "negative."

Principal components analysis (PCA) and visual inspection techniques were used to analyze the waveforms. Results of the PCA suggested that subjects distinguished word connotations at a time point of 1250 ms (or approximately 650 ms following the offset of the stimulus word). Visual inspection of the waveforms indicated that the right frontal lobe distinguished differences in word connotations, with the negative words demonstrating the higher amplitude of response. The right parietal lobe also distinguished differences in word connotations, with the positive words demonstrating the higher amplitude of response. Data obtained through visual inspection indicated greater activation of the right frontal and right parietal lobes for both positive and negative words, as compared to response

amplitudes in the left hemisphere. Response latencies were of longer duration in the left hemisphere of the brain.

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CHAPTER I

AUDITORY EVOKED POTENTIALS FOR WORDS WITH HIGH POSITIVE AND HIGH NEGATIVE CONNOTATIVE VALUES

I. INTRODUCTION

The meaning of words may be defined as denotative and connotative. Denotative is a dictionary definition. Connotative meaning essentially is "meaningfulness." Webster's Ninth New Collegiate Dictionary (1991) defined the word connotation as, "1a: something suggested by a word or thing: IMPLICATION. b. the suggesting of a meaning by a word apart from the thing that it explicitly names or describes (p. 311)." The connotation of a word, therefore, is an implication which exists beyond its denotative meaning. Speakers assign various attributes to words based on prior life experiences with those words (i.e., words may have the same meaning, but different connotations for different people). All words are assigned various positive and/or negative connotations by the speaker and listener, and these connotations are "weighted" so that a particular value is apportioned for these words. The word "forest," for example, denotes "a large tract of land covered with trees and underbrush" (Mish, 1991, p. 483).

However, a Californian might envision a large stand of redwood trees while contemplating a "forest," or a North Carolinian might imagine a mountainous slope of pine and Balsam fir, based on his prior life experiences. A teacher's aide used to provide a positive influence in the classroom environment, but now a teaching assistant accomplishes the same task due to the recently acquired negative connotations associated with the former title.

Osgood, Suci, and Tannenbaum (1959) determined that the various connotations associated with a given word can be measured behaviorally, independent of the word's meaning, through the use of their semantic differential scale. In the processing that occurs in the central auditory nervous system (CANS), are there measureable differences in the responses to words that differ in connotation--as there are for signals that differ in other ways? Late auditory evoked potentials were used in this study to measure CANS activity that may be sensitive to differences in semantic connotation. In the following sections, the bases for an electrophysiological measure of semantic connotation are discussed in terms of the behavioral measurement of connotation and electrophysiologic measurement of CANS function for connotation and related phenomena.

The Semantic Differential Scale

The semantic differential scale (Stagner & Osgood, 1946) was developed originally to study social stereotypes. Later, it was employed successfully to study topics as diverse as esthetics, economics, advertising, and multiple personalities (Brown, 1958; Snider & Osgood, 1969). Osgood et al. (1959) altered the original scale slightly to provide a reliable methodology for quantifying word meaning (Osgood et al. 1959; Messick, 1969; Flavell, 1969). The semantic differential scale utilizes a seven point rating system similar to the rating systems applied in many psychological assessments. The subject is required to make a semantic judgement of a given word's meaning based on her prior experience with that word. Values for positive words can be as high as +3.0, and negative words have values as low as -3.0. Words which are neutral, that is, those words which are neither negatively or positively valued, receive a rating of 0. The semantic differential scale was used in this study to measure the meaning of words behaviorally.

Event-Related Potentials

Picton (1988) defined event-related potentials (ERPs) as "changes in voltage ('potential') that occur at a particular time before, during or after ('related') something that happens in the physical world and/or some psychological process ('event')" (p. 1). These alterations in the brain's electrical activity occur when a stimulus is evaluated cognitively or perceptually. ERPs can be elicited with visual, auditory, or somatosensory stimuli. The present study used auditory evoked potentials to look for variations in the brain's response to connotatively different words. Most studies conducted to date used visual evoked potentials (VEPs) to determine whether the brain responded differently to words with different connotations (Chapman, 1974b; Chapman, Bragdon, Chapman, & McCrary, 1977; Chapman, McCrary, Chapman, & Bragdon, 1978; Chapman, McCrary, Chapman, & Martin, 1980). Molfese (1985) measured differences in auditory evoked responses for denotatively opposite words (i.e., tall-short).

Visual Evoked Potentials

In the mid-1970s and early 1980s, Chapman and his associates conducted a series of studies to establish a correlation between

VEPs and word meaning (Chapman, 1974b; Chapman et al., 1977; 1978; 1980). They used the semantic differential scale (Osgood et al., 1959) in conjunction with visual evoked potentials (VEPs) to examine the relationships among behavioral and neural responses and word meaning. Their results indicated that "representations of connotative meaning of stimulus words exist in brain activity recorded from the scalp" (Chapman et al., 1980, p. 336).

Begleiter, Gross, and Kissin (1967) studied the differential effects of VEPs for pleasant, neutral, and unpleasant affective stimuli. They determined that there were different VEP responses for words in each of these categories. In a similar study, Begleiter and Platz (1969) studied VEPs for taboo words, neutral words, and blank flashes. Their results indicated that VEP waveforms were different for the endogenous components of the evoked response in each category, with taboo words eliciting VEPs with the highest amplitudes. No similar effects have been demonstrated using AEPs as the measure of brain function.

Auditory Evoked Potentials

The AEP is a response measure which "refers to a portion of the ongoing EEG activity of the brain that can be elicited in response

to specific and discrete auditory stimuli" (Molfese, 1985, p. 290). Bierwisch (1967) and Katz (1972) suggested that words have bundles of positive and negative semantic features which allow listeners to distinguish among various word meanings. Molfese (1985) used AEPs to study these denotative semantic features. His results supported the semantic feature hypothesis proposed by Bierwisch (1967) and Katz (1972), in that underlying word representations were determined effectively through AEP procedures. His study remains an isolated effort in an attempt to relate AEPs to word meaning.

II. STATEMENT OF THE PROBLEM

Chapman and his associates (Chapman, 1974b; Chapman et al., 1978; 1979; 1980), Begleiter, Gross and Kissin (1967) and Begleiter and Platz (1969), determined that VEPs can be used to detect differences in word connotations. Molfese (1985) found that AEPs can be used to discriminate between the positive and negative semantic denotative features of words. However, to date, no one has used AEPs to measure responses to words with positive and negative connotative values as quantified by Osgood's semantic differential scale. The present study was undertaken to

determine if spoken words that differ in connotation result in AEPs that are different.

III. IMPORTANCE OF THE PROBLEM

This study is important because it is not yet known whether AEPs can be used in a normal language population to discriminate words with different connotations. It is an attempt to determine whether the electrophysiological responses to connotatively disparate words are similar or different among an homogenous group of subjects.

IV. PURPOSE OF THE STUDY

The purpose of this study was to determine if spoken words that differ in connotation result in different brain activity as measured using late auditory evoked potentials. AEP activity was studied in three regions of the brain (frontal, central, and parietal regions) and separately for the two hemispheres. The AEP measures examined included the amplitudes of the waveforms and the response latencies. A principal components analysis (PCA) was conducted to provide a comparison for the results of the AEP measures.

V. EXPERIMENTAL QUESTIONS

This study was designed to test the following hypotheses:

I. Does the principal components analysis indicate that there are differences in the AEP responses to positively vs. negatively valenced words at the central zenith electrode site?

II. Is there a difference in the amplitude of the AEP responses to positively vs. negatively valenced words?

III. Is there a difference in the latency of the AEP responses to positively vs. negatively valenced words?

IV. Is there a difference in the lateral amplitudes and latencies of the AEP responses to positively vs. negatively valenced words?

This study was designed to determine if there are differences in the AEP responses to words that differ significantly in connotation. Differences were examined for overall AEP, cerebral hemispheres, and brain regions. The AEP measures included a principal components analysis and a visual inspection of the amplitudes and latencies of P3 waveforms.

CHAPTER II

REVIEW OF THE LITERATURE

I. LATERAL DOMINANCE OF LANGUAGE FUNCTION AND HANDEDNESS

Broca (1865) first proposed that language is a left hemisphere function after he studied brain lesions in eight aphasic patients. Broca also recognized that manual preference and left hemisphere dominance for language were linked. Subsequent studies on lateralization of language function indicated that Broca's initial hypotheses were basically correct.

Luria (1947) examined World War II soldiers who suffered from head injuries to determine cerebral dominance. He found that 61 out of 64 right-handed patients experienced severe aphasia following traumatic brain injury, while the remaining three patients had mild aphasias due to their injuries.

Lecours, Lhermitte, and Bryans (1983) studied patients who sustained left hemisphere damage following cerebral vascular accidents. They found that more than 95% of their subjects suffered from aphasia. In another examination of stroke patients, Kimura (1983) determined that 95 out of 216 right-handed subjects were

aphasic following left hemisphere damage, while only three out of 169 right-handed patients suffered from aphasia following damage to the right hemisphere.

Penfield and Roberts (1959) demonstrated that approximately 95% of their subjects experienced aphasic episodes when the left perisylvian cortex was electrically stimulated during brain surgery, while virtually none were aphasic when the right hemisphere was stimulated. Milner (1974) injected barbituates into the left carotid arteries of her subjects, and she found that more than 98% of right-handed subjects experienced some transient aphasic language disturbances.

While Broca (1865) was correct in his assumption that most right-handed individuals were left hemisphere dominant, he also theorized that left-handed individuals were right hemisphere dominant for language function. Subsequent studies have indicated that he was wrong in this assumption. Goodglass and Quadfasel (1954) studied 123 left-handed aphasics with unilateral damage to one hemisphere. They found that 82% of their subjects with left hemisphere lesions suffered from aphasia, while 86% with right hemisphere lesions were aphasic. These results suggested that in left-handed subjects, both hemispheres often contribute to language function. Russell and Espir (1961) determined that 36% of their left-handed patients experienced aphasia following damage to the

left hemisphere, and that only 13% of their subjects with right hemisphere damage were aphasic. Milner (1974) determined that 51 out of 74 left-handed patients that she studied were left hemisphere dominant for language, 13 were right-hemisphere dominant, and 10 had bilateral language representation.

These studies indicated that the lateralization of language function was very different for right-handers vs. left-handers. Most of the research conducted to date confirmed that language is a left-hemisphere function for the vast majority of right-handed individuals. On the other hand, language dominance for left-handeders was not as well-defined. While most left-hand dominant individuals experienced aphasia following damage to the left hemisphere of the brain, a significant number of individuals with damage to the right hemisphere also become aphasic.

The Edinburgh Handedness Inventory (Oldfield, 1971) was administered to each of the subjects participating in this project, and only right-handed subjects were selected to preclude the possibility that handedness would affect the results obtained in the data analysis (see Appendix A).

II. THE SEMANTIC DIFFERENTIAL SCALE

The semantic differential scale was developed initially by Stagner and Osgood (1946) to study social stereotypes. This scale was later refined by Osgood, Suci, and Tannenbaum (1957) to quantify the way in which word meanings vary in a multidimensional semantic space. Osgood, et al. (1957) found that it was much easier for subjects to judge word meanings when given a semantic differential scale than to spontaneously encode word meanings. This led them to devise the scale as a variation of the "Twenty Questions" game where "the selection of successive alternatives gradually eliminates uncertainty as to the object being thought about, so selection among successive pairs of common verbal opposites should gradually isolate the 'meaning' of the stimulus sign" (Osgood, et al., p. 20). The "concept" acts as the "stimulus" providing a terminal "response" completed when the subject checks a given box on a given scale. In other words, the subject is provided with a concept to differentiate and a list of bipolar adjectives which incorporate a seven point scale indicating the direction, and the intensity, of the connotations associated with a given word. For example, the word "mother," which generally denotes "a female parent," also connotes "love, warmth, nurturing" etc., for many people. However, there are those who were orphaned as youngsters, or those born into abusive and destructive home

environments. For them, the word "mother" may connote something very different. The semantic differential attempts to sort out such differences in word connotations in an objectively quantifiable format.

A scale for the word "mother" might, therefore, look like this:

MOTHER

HAPPY	___:___:___:___:___:___:___	SAD
YOUNG	___:___:___:___:___:___:___	OLD
PLEASANT	___:___:___:___:___:___:___	UNPLEASANT
ACTIVE	___:___:___:___:___:___:___	PASSIVE
	+3 +2 +1 0 -1 -2 -3	

where +3 = "very happy," "very young," "very pleasant," etc., +2 = "moderately ...," +1 = "slightly ...," 0 is neutral, -1 = "slightly sad," "slightly old," "slightly unpleasant," etc., -2 = "moderately ..," and -3 = "very ..."

The subject places an "X" on the appropriate numbered line for each bipolar adjective. When provided with this type of linguistic output, high validity is presumed unless the honesty of the subject is questioned, and there is no more reason to expect intentionally wrongful responses to occur on a test of this sort than on any other

similar psychological test (Osgood et al., 1957).

The semantic differential scale (Osgood, Suci, & Tannenbaum, 1957) played a brief, but important, role in Phase I of this study. It was used to develop a list of 20 words, 10 with high positive and 10 with high negative values, which were used in Phase II of the experiment. The semantic differential scale was developed to provide a method which could reliably and accurately measure the connotative, or implied, meanings of words. It consists of a series of seven point scales, similar to the scales used in some psychological evaluations, in which subjects rate the meaning of words based on their prior experience with those words. For example, if given the word "crime," a subject might be asked to determine whether this word is "good" or "bad." If the subject believed that this word was bad, then he might give "crime" a value of -3 (very bad), -2 (somewhat bad), or -1 (slightly bad), depending on his semantic judgement of the word. If the word was neither good nor bad, the subject would give "crime" a value of 0. If the word "crime" had positive connotations for the subject, then a rating of +1, +2, or +3 might be given, depending on how positive this word was to him. The subject might also be asked to rate the word "crime" as "hot" or "cold," "ugly" or "beautiful," "fast" or "slow," on scales which appear to be unrelated to the word "crime." However, the subject is forced to choose the value which most closely resembles the meaning of the word for him.

For the word "crime," the scale might look like this:

CRIME

good	___ : ___ : ___ : ___ : ___ : _X_ : ___	bad
hot	___ : ___ : _X_ : ___ : ___ : ___ : ___	cold
beautiful	___ : ___ : ___ : ___ : ___ : ___ : _X_	ugly
fast	___ : _X_ : ___ : ___ : ___ : ___ : ___	slow
	+3 +2 +1 0 -1 -2 -3	

In this example, the subject's value for the word "crime" would equal -2 for the good-bad scale, +1 for the hot-cold scale, -3 for the beautiful-ugly scale, and +2 for the fast-slow scale. Adding these values together gives the following equation: $-2 + (+1) + (-3) + (+2) = -2$. The value associated with the word "crime" in this instance is -2, indicating that the word has a somewhat negative connotation for the subject. The operational meaning of the concept "crime" could be defined even more precisely by adding more scales. A word with a high positive connotation would have a value between +1.0 and +3.0. A word with a high negative connotation would have a value between -1.0 and -3.0.

Osgood, Suci, and Tannenbaum (1957) wrote The Measurement of Meaning, a "progress report" on the semantic differential, which

contributed significantly to psychological and linguistic studies in the 1960's and 1970's. While some researchers (Howe, 1969; Staats & Staats, 1969) were skeptical of the semantic differential scale's capacity to quantify the elusive nature of meaning, Osgood et al. (1957) may have anticipated the recalcitrance and hesitation of scientists when he wrote:

> Apart from the studies to be reported here, there have been few, if any, systematic attempts to subject meaning to quantitative measurement. There are probably several reasons for this, even in a period of intense objectivity in psychology: For one thing, the term "meaning" seems to connote, for most psychologists at least, something inherently nonmaterial, more akin to "idea" and "soul" than to observable stimulus and response, and therefore to be treated like the other "ghosts" that J.B. Watson dispelled from psychology. For another thing, it certainly refers to some implicit process or state which must be inferred from observables, and therefore it is the sort of variable that contemporary psychologists would avoid dealing with as long as possible. And there is also, undoubtedly, the matter of complexity--there is an implication in the tradition that meanings are uniquely and infinitely variable, and phenomena of this kind do not submit readily to measurement. (p. 1)

While the semantic differential scale is not without its

shortcomings, Osgood and others (Messick, 1969; Solley & Messick, 1969; Flavell, 1969) have demonstrated that this tool does, in fact, quantitatively measure meaning in a manner useful to researchers.

In their early research efforts, Osgood et al. (1957) discovered that whenever a large, representative sample of concepts was used in a semantic differential study, three primary factors emerged in trial after trial. Osgood et al. referred to these factors as the evaluative, potency, and activity factors, and they occurred in the same relative order of magnitude regardless of the concepts used.

In order to select a set of representative scales, Osgood and Suci (1957) conducted a factor analysis of 50 bipolar adjectives using Thurstone's (1947) Centroid Factor Method. They selected words for the scales by utilizing a frequency-of-usage and an availability criterion. A factor analysis was conducted on a correlation matrix (50 scales x 100 subjects x 20 concepts), and four factors were extracted and rotated. The authors discontinued the factor rotation after the fourth factor because the fifth factor accounted for only two percent of the total variance.

The evaluative factor was largest, and it accounted for one-half to three-fourths of the total extractable variance. This factor included bipolar adjectives such as "good-bad," "beautiful-ugly," and "pleasant-unpleasant." With the evaluative factor, the subject was required to evaluate the meaning of the word. It was considered an

attitudinal variable, which encompassed human thought, and it was based on "the bedrock of rewards and punishments both achieved and anticipated" (Osgood et al., 1957, p. 72).

The potency factor was second largest in magnitude, and it consistently accounted for approximately one-half of the total variance of the first variable (the evaluative factor). Potency was associated with power, and it included scales such as "strong-weak," "big-little," and "rich-poor." Snider and Osgood (1969) reported that one of their undergraduate statistical assistants referred to the potency factor as the "football player" (p. 47) factor.

The third largest variable was the activity factor. This factor, like the second, appeared to account for approximately one-half the variance of the evaluative factor. Scales associated with activity included "fast-slow," "sharp-dull," and "active-passive." Bipolar adjectives indicating warmth, excitement, quickness, and agitation were also exemplified by this factor.

Gabrielsson (1973) reported that the semantic differential technique was developed to measure the "meaning" of various concepts. However, it also was used by researchers to study social attitudes, experimental semantics, esthetics, economics, linguistics, advertising and multiple personalities (Brown, 1958; Snider & Osgood, 1969). Snider and Osgood (1969) suggested that some skepticism regarding the value of the semantic differential may result due to the

nebulous nature of meaning. They said:

> ...it is because of the philosophical haziness of this concept, perhaps because of the general belief that "meanings" are infinitely and uniquely variable, or perhaps because the word "meaning" as a construct in our language connotes mental stuff, more akin to "thought" and "soul" than to anything observable-- (p. 5)

that some researchers may continue to underestimate the semantic differential's potential in scientific inquiries. It is interesting to note, however, that the nature of, and change in, meaning is a core component around which many current scientific theories are constructed (Snider & Osgood, 1969).

While many researchers refer to the semantic differential as though it were some kind of test (Osgood et al., 1959), this really is not the case. Rather, the technique offers "the allocation of concepts to a common semantic space defined by a common set of general factors, despite variability in the particular concepts and scales employed" (Osgood et al, 1959, p. 76). The scales and concepts are not standardized, and should vary according to the purposes of the study for which they are used. The form and class of selected concepts, then, is determined by the nature of the problem to be studied.

III. ERP INVESTIGATIONS OF WORD MEANING

Event-related potential (ERP) research has intensified during the past three decades because ERPs are reliable and consistent measures of the brain's electrophysiologic response to auditory, neurotologic, neurologic and cognitive stimuli (Jacobson, 1994). ERPs are used to study neurologic disorders as diverse as Alzheimer's disease and dementia (Neshige, Barrett, & Shibasaki, 1988; Patterson, Michalewski, & Starr, 1988), aphasia (Selinger, Prescott, & Shucard, 1989), multiple sclerosis (Newton, Barrett, Callanan, & Towell, 1989), autism (Niwa, Ohta, & Yamazaki, 1983), and epilepsy (Rodin, Khabbazeh, Twitty, & Schmaltz, 1989). ERPs are also used to study normal aspects of speech and language including phonology (Cohn, 1971; Hillyard & Woods, 1979; Neville, 1980), syntax (Thatcher, 1976; Brown, Lehmann, & Marsh, 1980), and semantics (Chapman, McCrary, Chapman, & Bragdon, 1980). Recent studies also used ERPs effectively to assess the integrity of the ascending auditory pathway (Chiappa, 1990; Hall, 1992).

This study evaluated ERPs in a normal adult population. Auditory evoked potentials (AEPs) were used to measure responses to words with positive values and words with negative values. It was hypothesized that cortical activity would be different for the two groups of words.

Evoked Response Potentials

Berger (1929) first noted that electrical activity generated from the central nervous system (CNS) could be recorded from the scalp. This electrical activity occurred even in the absence of sensory stimulation, and the resulting random, spontaneous neural events were recorded by attaching electrodes to the scalp. The recording of these neural events was called an electroencephalogram, or an EEG. Loomis, Harvey, and Hobart (1938) later determined that these EEG patterns were altered when sensory stimuli were introduced to their human subjects. The finding that these stimulus-related events could be extracted and identified from ongoing EEG activity provided the foundation for current use of evoked response potentials (Jacobson, 1994).

Auditory evoked potentials (AEPs) are divided into three temporal periods, or epochs. Brain electrical activity can be measured during each epoch by averaging the sum of neuroelectric responses to a time-locked, repetitive stimulus presentation (Clark, 1958; Clark, Goldstein, Brown, Molnar, O'Brien, & Zieman, 1961). These epochs include the early components (lasting from 0 to 10 ms), the middle components (lasting from 10 to 80 ms), and the late components (lasting from 100 to 900 ms).

The early components, generally called the auditory brainstem

response (ABR), consist of seven peaks or waves which are measured in less than 10 ms following the presentation of an acoustic stimulus. Wave I (P2) consists of the summated action potentials evoked by fibers of the auditory nerve; Wave II (P3) most likely originates from the cochlear nucleus, Wave III (P4) from the superior olivary complex, Waves IV and V (P5, P6) from the midbrain (probably from the lateral lemniscus and inferior colliculus respectively), and Wave VI (P7-P12) from above the midbrain level (Hillyard & Woods, 1979). The ABR is considered exogenous because variance in the ERPs is outside of the physical parameters of the eliciting stimuli (Donchin, Ritter, & McCallum, 1978).

The middle latency response (MLR) includes auditory evoked potentials which are thought to originate at the level of the thalamus. These AEPs have a latency response range of 8 to 80 or 100 ms following the onset of a transient sound according to Goldstein (1973), although the MLR is sometimes thought to occur between 10 to 50 ms following the presentation of an acoustic stimulus. The MLR is comprised of waves Na (18 ms), Pa (30 ms), and P1 (50 ms). The MLR is used clinically to assess cochlear implant function, to determine low frequency hearing thresholds, to assess the integrity of the auditory pathway, and to localize lesions along the auditory pathway (Jacobson, 1994). The MLR is used in combination with the ABR to evaluate the function of the auditory brainstem pathways. It

is also used to assess damage to the higher auditory pathway (Kraus, Odzamar, Hier, Stein, 1982), and to reflect activity of the reticular activating system (Buchwald, Hinman, Norman, Huang, & Brown, 1981).

The late component of the AEP begins at approximately 100 ms following the introduction of an auditory stimulus. Approximately 100 ms following the introduction of a stimulus, there is a negative wave (identified as N1). This waveform corresponds to the arrival of the auditory stimulus at the level of the cortex. A positive wave (P2) occurs at approximately 150-200 ms, indicating that the stimulus is being evaluated acoustically. At this positive deflection of the wave (P2), the auditory signal is considered endogenous; that is, the response is a function of the parameters of a given stimulus (Donchin, Ritter, & McCallum, 1978). It is at this point that "the various characteristics of the EP waveforms, although triggered by some stimulus, are affected by the cognitive-perceptual processes involved in processing the stimulus" (Molfese, 1987, p. 424). Another positive wave (P3) may occur as early as 250 ms after the onset of the signal, but the latency may be 900 ms or more, depending on the time duration of the signal and the processing time for the task. According to Donchin (1979), P3 latency lengthens with increasing complexity of the task-relevant stimuli. This signal occurs when a novel event is processed in the cortex.

The general hypothesis for this study was that auditory evoked

potentials for words with high positive and high negative values are different. While some studies which utilized visual ERPs were published on this subject in recent years (Chapman, 1974b; Chapman, et al., 1977; 1978; 1980; Begleiter, Gross, & Kissin, 1967; Begleiter & Platz, 1969), only Molfese (1985) used AEPs to study the positive and negative features of words. No studies conducted to date indicate definitively whether there are differences in the amplitude, the latency, or the laterality of the AEP responses to words with positive and negative connotations. It may be possible, however, to draw certain conclusions from studies which utilized VEPs.

Visual and Auditory Evoked Potentials

Chapman and his colleagues (Chapman 1974b; Chapman, 1978a; 1978b; 1978c; Chapman et al., 1979; 1980) used multivariate statistical analyses, including principal components analysis, to positively demonstrate that "representations of connotative meaning of stimulus words exist in brain activity recorded from the scalp" (Chapman et al., 1980, p. 336). Their approach was based on the semantic differential rating procedure developed by Osgood, Suci, and Tannenbaum (1959). They specifically observed the relationships among behavioral and neural responses and the connotative meaning of words.

Molfese (1983, p. 1) wrote that "little specific information is currently known concerning the electrophysiological correlates of language," and that this particularly was true in the study of connotative word meanings. He also reported that despite the relatively large number of ERP studies conducted through 1983 (more than 100), the information derived from these studies was insufficient to provide specific conclusions regarding the measureability of language utilizing ERP research. Molfese (1983) said that this slow progress may be attributed to:

> (1) the general lack of systematic research except in only a few studies, etc.; (2) a simplified view of language coupled with the absence of an overall linguistically oriented approach to guide stimulus selection and control as well as experimental design; (3) the more prevalent interest in ERP demonstrations of laterality--a situation that may have distracted investigators from identifying specific ERP differences to language related stimuli; (4) the use of inappropriate analysis procedures or the absence altogether of objective statistical techniques; (5) conclusions that over-generalize from the absence of effects or which ignore effects not in keeping with the hypothesis being advanced. (Molfese, 1983, p.1)

Since he made this statement, only one other study was located

(conducted by Molfese, 1985) which attempted to link AEPs with word meaning.

In addition to problems with research design, Fischler (1990) noted that the series of ERP studies conducted by Chapman et al. (1980), in which they measured the connotative or affective meaning of words, "remain a relatively isolated effort" (p. 169). According to Fischler (1990), "There have been few ERP investigations of the conceptual and semantic properties of individual words" (p. 169).

Chapman and Bragdon (1964) published the first of a series of articles mapping the relationship between averaged evoked potentials and "meaningfulness." They recorded evoked responses to numerical and non-numerical visual stimuli while subjects performed a problem-solving task. The stimuli consisted of white luminous numbers, blanks, and plus signs which were presented visually and sequentially. The authors concluded that the waveforms for numbers and for blanks were significantly different, and that the luminance of the visual stimuli did not account for these differences. They also determined that the larger evoked response components were derived from the central-parietal electrode rather than from the occipital electrode.

Chapman and Bragdon did not relate any information concerning the number of subjects used, their age, sex, handedness, or visual acuity in this study. Additionally, by graphing the evoked responses of only

two experimental subjects in separate tables, and by not discussing the data obtained in other subject measurements, they failed to recognize the significant potential for bias in their results.

Chapman, Bragdon, Chapman, and McCrary (1977) discussed the interrelationship between averaged evoked potentials and semantic word meaning. The authors outlined Osgood's analysis of semantic meaning (Osgood, 1952; Miron & Osgood, 1966; Osgood, 1971), discussing the evaluation, potency, and activity dimensions in detail. They emphasized the importance of intralinguistic variation, or the variability of word meaning within a given language, provided by linking EP effects with the semantic differential scale effects. In this study, Chapman et al. (1977) selected words from six semantic meaning classes (Evaluation+, Evaluation-, Potency+, Potency-, Activity+, Activity-), thus representing the extremes of the E, P, and A dimensions. The authors developed two lists of 20 words from each of the six classes and visually presented them in random order to three women and nine men ranging in age from 18-55. The authors analyzed evoked potential (EP) data obtained from electrodes placed at one third of the distance from the central zenith (CZ) to the parietal zenith (PZ), and they monitored eye movements with electrooculogram (EOG) averages. EPs were averaged over a 510 msec duration beginning with the presentation of the stimulus word, and the subjects were required to say each word aloud following the

presentation. The words were from three to 13 letters in length, with an average length of 5.5 letters.

The authors focused their data analysis on the E+ and E- classes of words. The authors subtracted the average E- responses from the average E+ responses and concluded that "differences on the evaluative dimension of visually presented words resulted in detectable and statistically reliable differences in brain responses" (p. 43). Results for the potency and activity dimensions were encouraging, but were not as strong as the results for the evaluative dimension. This correlated well with Osgood et al.'s (1957) finding that the evaluation dimension accounts for the largest amount of variance in the connotative values of words, followed by the potency, and then the activity dimension effects.

The Chapman et al. (1977) study was significant because it established the idea that differences on the evaluation, and, to a lesser extent, differences on the activity and potency dimensions, may be distinguished through an analysis of brain response averages. These results supported the conclusion that EP responses to words are related to linguistic processing. However, differences in subjects' age, sex, and left/right hand dominance were not considered in this study.

In a similar attempt to establish a correlation between brain electrical activity at the scalp and semantic meaning, Chapman,

McCrary, Chapman, and Bragdon (1978) again compared evoked response potentials for six semantic classes of words (E+, E-, P+, P-, A+, A-). Through the use of multivariate analyses, the authors concluded that brain activity patterns showed different waveforms for each of the six semantic classes. These results were consistent for each of the 10 subjects studied and for both word lists, suggesting that it is possible to infer internal representations of meaning through the analysis of electrical brain activity. Chapman et al. (1978) concluded that "the physiological representation of meaning may be similar in different individuals. Further substantiation of the finding would parallel, at the physiological level, the universality of the Osgood dimensions found by semantic differential ratings" (p. 204).

In the experimental design for another study, Chapman et al. (1979) required subjects to listen to alphabetical letters (A-F) and numbers (1-6) presented in a random sequence. Ten letter-relevant runs and 10 number-relevant runs were presented in random order over five sessions. The subjects reported which letter or number was lower in alphabetical or numerical order for each trial. Chapman, et al. recorded EEGs from CPZ, and linked ear lobes were used as the reference.

The authors used the BMDX72 program developed by Dixon (1972) to transform the data matrix obtained during the trial runs into a

correlation matrix. Eight principal components (a relatively large number), which accounted for 96.4% of the total variance in the original measures, were extracted. These eight components were then rotated using a normalized varimax criterion (Kaiser, 1958).

The information derived from these computations indicated that each of the eight components were functionally meaningful, and the time courses for each component were consistent with prior research information. Chapman et al. concluded that the information provided by principal components analysis is sufficiently sophisticated to sort out EP components that are "related to specific, meaningful operations in central processing of information" (p. 105).

This study demonstrated the usefulness of principal components analysis when analyzing data provided from EP studies. The multivariate statistical technique, when combined with visual inspection of the waveforms and measurement of the amplitudes and latencies of various EP components, furnishes a powerful approach to determine which specific EP components may be related to various functions of information processing.

Relating the later components of ERPs to information processing, Chapman et al. (1979) noted that an EP measurement taken at any given moment in time is representative of a composite of events comprised of various component operations and activities. They said that:

> ...the EP is neither a monolithic entity nor are the measures at the various time points completely discrete and independent of each other. The EP is composed of a number of components occurring at varying times after a stimulus, some of them overlapping in time while others may occur sequentially. (p. 80)

In their research design, the authors studied the relationship among identifiable components of information processing tasks and specific components of the EP response.

Of the various techniques used to measure EPs, certain analyses provide more consistent and reliable data than others (Chapman et al., 1979). One of the more common measurement techniques is the visual inspection method. While it is important and necessary to include representative EP waveforms in publications, complete reliance on visual inspection is problematic. The authors noted that "most regrettably, the potential wealth of quantitative information contained in the EPs is essentially left unappreciated" (p. 81) when the visual inspection method is used in isolation.

Another common technique is exemplified in the practice of measuring positive and negative amplitudes and subject response latencies, which provide data essential to the statistical and quantitative analysis of waveforms. This approach is very useful because it allows the researchers the opportunity to compare and

contrast specific changes in the EP waveform with changes in the experimental conditions. Chapman et al. (1979) warned, however, that measuring positive and negative peaks along the timeline tends to treat each amplitude peak as an isolated and meaningful event which, in fact, ignores the potential contributions of underlying latent components. There is also an inherent difficulty in identifying which peaks to measure; and frequently, only a few points along the timeline are considered, thereby leaving a significant portion of the data unanalyzed.

Chapman et al., (1979) suggested that in addition to the previously described techniques, a practical measurement system should:

> (1) *represent* the data in a concise, *parsimonious* way; (2) *determine* EP *components* from the data without assuming in advance any particular waveforms for the components (e.g. why assume that sine waves are functional components?); (3) extract components which are *independent* of each other; (4) *measure* the amount (contribution) of various components in observed EPs; (5) have measures which have greater *reliability* than measures at any single time point or peak, and (6) identify and measure components which somewhat *overlap* in time. (pp. 81-82)

Chapman et al. (1979) concluded that a type of multivariate

statistics, called principal components analysis, fulfills each of these requirements. They wrote: "Principal components analysis gives not simply a parsimonious representation of the data, but the *most* parsimonious representation to any given level of accuracy (percent variance explained)" (p. 82). In a related article on this subject, Regan (1972) reported that this method is two to four times more accurate than Fourier analysis. According to Chapman et al., (1979) principal components analysis allows for a determination of all EP components, and it measures "how much of each component is in each EP" (p. 82). Overall, this study was important in that it provided an impetus for further use of principal components analysis as a reliable analytical technique for future VEP studies.

In their article, "Behavioral and Neural Analysis of Connotative meaning: Word Classes and Rating Scales," Chapman, McCrary, Chapman, and Martin (1980) used visual evoked-response potentials to observe the relationships among behavioral and neural responses and the connotative meanings of words. The authors based their approach on Osgood's (1957) semantic differential rating procedure. Six female and four male paid volunteers, ranging in age from 18-50 years (median age: 21), participated in the study. For each run of the experiment, the subjects were given a list of 20 words which had been rated previously (Chapman et al., 1979) from each of six semantic classes [Evaluation (E+, E-), Potency (P+, P-), or Activity

(A+, A-)], for a total of 120 words per run. These words were extremely positive or negative on one scale dimension, and were neutral on the other two scale dimensions. For example, the word "speed" was rated as extremely active (A+) on the semantic differential scale, but was relatively neutral on the evaluation and potency dimensions (Osgood, 1965). In contrast, the word "silence" was rated as very inactive (A-), but it also maintained neutrality in the evaluation and potency dimensions (Chapman et al., 1978).

Prior to each experimental run of 120 words, the subjects were given a specific scale (e.g., GOOD-BAD), with which to rate each word on that run. The subjects then assigned a numerical value of +3, +2, +1, 0, -1, -2, or -3 to each word, depending on the degree of goodness (positive numbers), badness (negative numbers), or neutrality (zero), according to Osgood et al.'s (1957) procedures. A total of 15 semantic scales (five bipolar scales representative of each semantic dimension-- Evaluation, Potency, and Activity) were used with each stimulus word.

In this study, the researchers determined that visual evoked-potential responses were linked directly to semantic variables, and were unrelated to other types of variables. Specific brain responses were observed for the six semantic classes, for the Evaluation, Potency, and Activity scale dimensions, and for the 18 groups formed by their factorial combination. They also determined

that "different EP components tended to be important in discriminating (1) among the semantic word classes and (2) among the rating scale dimensions" (Chapman et al., 1980, p. 337). These results were important, for they implied that while the semantic differential related the stimulus word and the rating scales to the same underlying Evaluation, Potency, and Activity semantic dimensions at a behavioral level, it appeared that the effects of stimulus word and rating dimension were measured separately at the neural level. In other words, "there is a neural independence of the semantic class of the stimulus words and the semantic dimensions of the rating scales" (p. 337) which remains undifferentiated at the behavioral level. Ultimately, the researchers concluded that the connotative ERP effects at the neural level and the connotative dimensions of the semantic differential ratings at the behavioral level paralleled one another, and that these effects were universal across individuals (Chapman et al., 1980).

As critiqued in previous studies, Chapman et al. (1980) used subjects of both sexes. Ages ranged from 18 to 50 years, and no hand preference was acknowledged. Visual acuity of the subjects was not evaluated, and only two electrode measurements were used in the final analysis of the VEP data.

In a related study, Begleiter, Gross, and Kissin (1967) researched the differential effects of pleasant, neutral, and unpleasant affective

stimuli when visual evoked response potentials were measured. Their results indicated that it was possible to distinguish the affective quality of words (positive, negative, or neutral) through visual evoked responses, with greater amplitudes occuring for positive and negative stimuli as compared to neutral stimuli. This suggested that an interaction between the visual and emotional centers of the brain may exist. Begleiter et al., (1967) also found that negative stimulus latencies were significantly shorter than for the positive and neutral stimulus items. They hypothesized that this shorter latency may be the result of the organism manifesting "vigilance for anxiety-producing stimuli" (p. 342).

In the previous study, subjects were conditioned to associate meaningless figures (CS) with affective responses elicited by positive, negative, or neutral words (UCS). In a subsequent investigation, Begleiter, Gross, Porjesz, and Kissin (1969) studied how affective meaning influences cortical evoked potentials under two different experimental conditions. In the first condition, subjects were partially aware of the conditioning process, and in the second condition, subjects were told about both the CS-UCS contingency and the conditioning process. The results of this study were then compared with the data obtained in the first study. Research results indicated that there was a significant difference in the amplitudes of the visual evoked potential (VEP) to the three

conditioned stimuli for each of the three experimental groups.

Begleiter and Platz (1969) studied the influence of affectively loaded semantic stimuli on visual evoked potentials when taboo words, neutral words, and blank flashes were used as stimulus items. Eighteen male college students served as subjects for this experiment. The subjects looked at stimulus items through a viewing hood set up in an acoustic enclosure. The stimuli consisted of capitalized words two and one-half inches high and one-half inch thick mounted on a transparent background. Two sets of word stimuli were presented randomly for a total of 20 presentations, with each set containing a taboo word, a neutral word, and a blank field. The authors allocated a short stimulus exposure duration of 10 microseconds to ensure a transient visual pathway response, and interstimulus presentation intervals ranged randomly from two to four seconds.

In one investigative condition, subjects viewed all of the word stimuli passively, without responding. In the other condition, subjects were required to vocalize words presented on the screen, or to say "flash" for the blank field presentation. The conditions were differentiated to study the possible effects of subject involvement with the stimuli.

Results indicated that cortical evoked response amplitudes were significantly greater for the taboo words in both conditions than for

either the neutral words or the blank flash, with the flash eliciting the smallest response. Visual evoked potential amplitudes were larger for the vocalized response condition, possibly reflecting an added attention dimension required for this task, or emotional arousal induced by saying the taboo words aloud. The authors concluded that the affective meaning of the stimuli presented, and the responses required of the subjects, may both "affect the amplitude of the later components of the cortical evoked response" (p. 96).

IV. AUDITORY EVOKED POTENTIAL STUDIES

Molfese (1983) summarized ERP research in four areas of language study. He wrote the following:

> Although nearly one hundred scientific papers purporting to deal with evoked potential correlates of language processes have been published over the last three decades, little specific information is currently known concerning the electrophysiological correlates of language. This is especially true in the areas of syntax, semantics, pragmatics, and sentence processing. (p. 1)

He noted that while ERP research in phonology has received the most attention, and is the most systematically studied language aspect, even current information in this area is inadequate. He said

that many more studies are necessary in all aspects of language processes before a significant data base is collected. He criticized many of the investigations conducted to date, citing "numerous methodological flaws and the absence of a theoretical framework" (p. 22) inherent in research paradigms. He reported, however, that current research does indicate the importance of using ERPs to study phonological cues, syntactic/denotative semantic manipulations, and connotative meanings.

Molfese (1985) used auditory evoked responses (AERs) to study the positive and negative denotative features of various words. Bierwisch (1967) and Katz (1972) suggested that language systems rely on bundles of positive and negative semantic features to distinguish among various word meanings. According to this definition, the word "squirrel" contains semantic features such as "+ animal," "+ furry," "+ tree climber," "- feathers," and "- dangerous," to name a few. Therefore, the word "squirrel" is comprised theoretically of a finite set of semantic features which distinguish it from other words.

Molfese used ten right-hand dominant college undergraduate students with normal hearing acuity as subjects for this study. Twenty words were used as stimulus items, with the ten positive words including "more, high, wide, above, deep, front, up, over, before, and tall" (p. 291). The ten negative words included "less, low, narrow,

below, shallow, back down, under, after, and short" (p. 291). Note that the semantic features mentioned were part of the denotative meanings of words and not necessarily connotative. The twenty words were recorded in blocks of four on a stereo tape recorder channel for a total of 80 words. Scalp electrodes were placed at F3, F4, T3, T4, P3, and P4 according to the Jasper (1958) 10-20 system (see Appendix B).

Molfese determined from the results of this study that it was possible to distinguish semantically positive words from negative words using AER data, thus supporting the semantic feature hypothesis. The data indicated that underlying word representations may be determined effectively through AER procedures. Molfese did not believe that connotative differences associated with the words were responsible for the study outcome. He stated that numerous studies conducted by Chapman et al. (1977; 1979; 1980) found no correlation between the P300 component and differences in connotative meaning. He reported, "At this time, at least, it would appear that the AER as represented in the present study is sensitive to differences in semantic features rather than to the emotional impact of the words" (p. 296).

V. SUMMARY

The semantic differential scale was developed by Osgood, Suci and Tannenbaum (1957) to measure objectively the connotative, or implied, meaning of words. This scale was developed to quantify the way in which word meanings vary in a multidimensional semantic space. The semantic differential scale consists of a series of seven point scales which subjects use to rate the meaning of words based on their prior experience with those words. In their studies with this scale, Osgood et al. (1957) found that three primary factors emerged in the same relative order of magnitude regardless of the concepts used. These factors included the evaluative, the potency, and the activity factors. The evaluative factor was the largest, and it consistently accounted for one-half to three-fourths of the total extractable variance.

The research conducted by Chapman et al. embodied the bulk of evoked response potential studies which established a correlation between brain electrical activity at the scalp and semantic meaning. These authors used the Evaluative, Potency, and Activity dimensions derived from Osgood et al.'s (1957) semantic differential scale to determine whether differences in the E, P, and A dimensions may be distinguished through an analysis of brain response averages. The authors used a Principal Components Analysis in combination with

other statistical measures to evaluate their data. Although they recorded ERPs for Evaluative, Potency, and Activity dimensions, they focused their data analysis on the E+ and E- classes of words because results for the P and A dimensions were not as strong. This correlated well with Osgood et al.'s (1957) findings that the evaluative dimension accounted for the largest amount of variance in the connotative values of words, followed by the potency, and the activity dimensions. Chapman et al. showed that ERPs reliably measure differences in experimental stimuli, and that such stimuli can even be distinguished individually by their characteristic peak amplitudes and response latencies. They ultimately concluded that connotative ERP effects at the neural level and the connotative dimensions of the semantic differential ratings at the behavioral level parallel one another, and that these effects are universal across individuals (Chapman et al., 1980).

In a series of related studies, Begleiter et al. (1969) researched the differential effects of pleasant, neutral, and unpleasant affective visual stimuli on evoked response potentials. Their results indicated that it was possible to distinguish the affective quality of words through visual evoked responses, with greater amplitudes occuring for positive and negative stimuli as compared to neutral stimuli. They also found that negative stimulus word latencies were significantly shorter than for the positive and neutral stimulus items.

Molfese (1985) used auditory evoked responses to study the denotative values of positive and negative adjectives. He concluded that it was possible to distinguish positive words from negative words using AER data, thus supporting the semantic feature hypothesis.

CHAPTER III

METHODS AND PROCEDURES

The purpose of this study was to determine whether there is a measureable difference in auditory evoked response potentials when words with positive and negative connotations are presented to subjects. Chapter III delineates the various steps taken to procure the words used in this study and the procedures used to analyze the data.

I. SEMANTIC DIFFERENTIAL STUDY

Selection of Subjects

Fifteen female subjects were selected for this phase of the study. Subjects were between the ages of 18 and 35, and they were participants in undergraduate and/or graduate classes in Speech-Language-Pathology and/or Audiology at the University of Tennessee. Subjects had no known neuropsychiatric disorders, or any disorders [including Attention Deficit Hyperactivity Disorder (ADHD) or Central Auditory Processing (CAP) disorder] which might influence vigilance or attention to the task.

Construction of the Semantic Differential Scale

Osgood et al. (1965) reported that three factors (evaluation, potency, and activity) accounted for 96.67% of the common variance extracted when subjects made meaningful judgements of 20 varied concepts against 50 varied scales. Of these three, the evaluative factor accounted for "almost 70% of the common (extracted) variance" (p. 38). It was determined, therefore, that the evaluative factor played the dominant role when subjects made meaningful judgements regarding word meaning. For this reason, the current study focused on the evaluative factor in the classification of words.

Selection of the Scales

Scales were selected on the basis of their "high loading" for the evaluative factor as determined by Thurstone's (1947) Centroid Factor Method. The scales received various "loadings" on the evaluation, potency, or activity factors (as discussed in the literature review), depending on their content. Scales with high loadings on the evaluative factor included "good-bad, "beautiful-ugly," etc. The evaluative factor was an attitudinal variable which required the subjects to evaluate the meaning of a word. The potency factor included scales such as "large-small," "strong-weak," etc. This factor

was associated with power. The third factor appeared to be an activity variable in judgements, and it included words such as "fast-slow," "active-passive," etc. A high loading on any one of these factors indicated that this factor contributed most significantly to the extracted variance. Only those scales with a rotated factor loading of greater than .80 on the evaluative factor were used for this study, and they were selected from Table 1 shown in The Measurement of Meaning (Osgood, et al., 1965, p. 37). On the basis of these selection criteria, the following bipolar adjectives were used to represent the evaluative factor:

good-bad (.88)

nice-awful (.87)

beautiful-ugly (.86)

honest-dishonest (.85)

fragrant-foul (.84)

fair-unfair (.83)

sweet-sour (.83)

clean-dirty (.82)

kind-cruel (.82)

pleasant-unpleasant (.82)

Selection of Words

Forty words were selected for subjects to rate on the semantic differential scale. Monosyllabic words were selected so that they were approximately equal in length. Where available, words with high positive and high negative values were chosen from the Semantic Atlas for 550 Concepts (Snider & Osgood, 1969). The list of 40 words was rated by a group of 15 subjects. The 10 words with the highest positive mean values and the 10 words with the highest negative mean values became the stimulus items for the AEP measurements. That is, words which best represented the evaluative extremes were utilized. No words with values between +1 and -1 were included because such words would not be representative of the evaluative extremes required for this study. Individual responses for each of the 15 subjects on each of the 40 words were tallied and mean ratings were determined from their scores.

Stimulus Words

The 10 words with the highest positive values and the 10 words with the highest negative values were used to develop a stimulus tape. The mean semantic value of the 10 most positive words was +1.95, and the mean semantic value of the 10 most negative words

was -2.39. Table I on the following page shows the results of the semantic differential scale study.

The 20 words were arranged randomly on each of four separate word lists to provide a total of 80 stimulus items. The words were recorded and digitized, and when the digitizing sequence was completed, the average durations of the positive and negative words were calculated. The mean duration for the positive words was 499 ms, while the mean duration for the negative words was 479 ms. Therefore, there was a 20 ms difference in the mean durations of the positive vs. the negative words. This was an uncontrolled variable in the study. The word lists and triggers were transferred from the computer onto a cassette tape in stereo so that the words were on one channel and the triggers were on another. This cassette was then used as the stimulus tape for the study. Words were recorded utilizing a Sound Edit Pro program (Apple Computer, 1994) on a Macintosh PowerMac 6100. The recording utilized a carrier phrase ("The word is...") as an alerting technique to insure the subject's attention, followed by a two second pause and the word (e.g. "crime") to be evaluated. Approximately 100 ms prior to the onset of the word, a trigger signal (1000 Hz tone of 100 ms duration) was placed on a second channel of the tape recording to trigger the analysis program. Recording, averaging, and measuring of evoked responses was conducted by the EPACS analysis system (Molfese, 1988).

Table I. Average connotative values associated with positive and negative words during the Semantic Differential rating, their values, and their durations.

POSITIVE WORDS	VALUES	DURATIONS (ms)	NEGATIVE WORDS	VALUES	DURATIONS (ms)
1. PEACE	(+2.33)	496	RAPE	(-2.93)	400
2. PRAY	(+2.31)	463	KILL	(-2.71)	454
3. SPRING	(+2.25)	580	CRIME	(-2.67)	517
4. BRIDE	(+2.12)	567	HELL	(-2.39)	466
5. GOD	(+1.99)	512	ROB	(-2.38)	567
6. LOVE	(+1.97)	508	CHEAT	(-2.35)	390
7. KISS	(+1.96)	467	WAR	(-2.23)	488
8. JUNE	(+1.58)	503	STAB	(-2.13)	597
9. LIGHT	(+1.56)	413	MAIM	(-2.13)	563
10. LIFE	(+1.44)	485	BEAT	(-1.94)	348
MEAN	+1.95	499		-2.39	479

II. AUDITORY EVOKED POTENTIAL STUDY

Selection of Subjects

Subjects included in the auditory evoked potential study were selected according to the following criteria. They were:

a) female;

b) between 18 to 35 years of age;

c) attending graduate or undergraduate classes in Speech-Language Pathology and/or Audiology at the University of Tennessee;

d) subjects with normal hearing thresholds as determined by their passing a hearing screening at 15 dB HL at 1K, 2K, and 4K Hz.

e) subjects with no known neurological impairment.

f) right-hand dominant as determined by the short form of the Edinburgh Handedness Battery (see Appendix A) described by Oldfield (1971).

Presentation of the Stimuli

Taped stimuli were presented at approximately 70 dB HL at ear level from an overhead speaker located approximately one meter above the subject's head. A sound level meter was used to measure the intensity of the recorded stimuli prior to each trial run. Subjects were seated comfortably in a sound isolation room which met ANSI

(1991) standards for conducting audiological evaluations with uncovered ears.

Subjects were seated in a leather recliner. They were asked to move as little as possible, and they pushed one button when they heard a "positive word" or a second button when they heard a "negative word." The behavioral responses to both positive and negative words guarded against a contingent negative response which might be a contributing factor if only positive or negative words were targetted for responses.

Measurement of the Auditory Evoked Potential

The subject's scalp was abraded mildly, and standard electrodes were placed according to procedures described by Jasper (1958). The International 10-20 System may be reviewed in Appendix B. Six channels were recorded and analyzed, including the left and right frontal, left and right parietal locations, and frontal and central zeniths. Electrode impedance was checked pre- and post-test, and registered less than 10K ohms, with no more than a 5K ohm difference between electrodes.

Electrodes were connected by receptacles to Grass P5 (Model 511) AC pre-amplifiers with their own power supply (Grass) RPS #107, and set to amplify the auditory evoked responses by 100,000 times.

Frequency range settings were from .1 to 30 Hz. Three two-track (Tektronix 2201) oscilloscopes were mounted to allow for visual monitoring of artifactual (movement) signals. Signals were passed through an additional 45 Hz low pass filter to eliminate any 60 Hz hum. The amplified analog signals were passed through an analog-to-digital converter, and the digital signals were analysed in a Macintosh SE microcomputer utilizing the EPACS (Molfese, 1988) program. The electrical activity of the brain was recorded for 200 ten ms epochs during the presentation of each of the 80 stimulus words.

III. PROCEDURES FOR ANALYZING THE DATA

The Principal Components Analysis

A multivariate statistical procedure called Principal Components Analysis (PCA) was used to analyze each of the AEP components. The formatted files containing the waveforms for the 15 subjects were converted to text files utilizing the EPACS analysis system (Molfese, 1988). This process changed the averaged graphic data into 120 lines of numerical data which were analyzed during the factor analysis. The first 60 lines of data included information for condition *1 (the positive words), and the next 60 lines contained data for condition *2

(the negative words). The BMDX72 program (Dixon, 1972) was used to transform the data matrix obtained during the trial runs into a correlation matrix. The correlation matrix established the interrelationship between the various numbers (waveforms for words) to extract those waveforms (components) which accounted for the greatest amount of variance in the waveform. An ANOVA was then conducted on the extracted components to determine whether a significant difference existed among the components for condition #1 and condition #2. Each component was then rotated using a normalized varimax criterion (Kaiser, 1958).

The visual inspection technique also was used to study the waveforms, and positive and negative amplitudes and subject response latencies were analyzed. The operational definition for the P3 component was the greatest relative positivity in the latency range of plus 850 ms to 1500 ms (allowing for word durations of approximately 500 ms). A cursor was placed on the point of the greatest peak of the averaged waveform, and the baseline-to-peak number and the response latency (minus 100 ms for the baseline) provided by the EPACS software program, were recorded. This provided information pertinent to the statistical and quantitative analysis of the waveforms.

Reliability

Three subjects were selected at random, and their responses to the auditory evoked potential stimuli were recorded a second time approximately two weeks after the initial trial. Presentations one and two then were compared to determine whether there were any significant differences in responses. No significant differences were noted for response amplitudes or response latencies for the subjects, and retest results were similar to initial testing results.

A second independent examiner familiar with the visual inspection technique also analyzed the waveform response latencies and amplitudes to determine the validity of the original data analysis. His results correlated closely with those of the first examiner.

CHAPTER IV

RESULTS

I. THE PRINCIPAL COMPONENTS ANALYSIS

The purpose of this study was to ascertain whether there were differences in the Auditory Evoked Potentials (AEPs) for words with high positive and high negative values. In particular, this study was designed to determine whether there were differences in the response amplitudes, the response latencies, and/or the laterality of responses to positively vs. negatively valenced words. A principal components analysis (PCA) was conducted to determine whether there were significant differences in the brain's response to positively vs. negatively valenced words. Chi-square tests were then applied to the data to determine whether there were significant differences in waveform amplitudes and latencies for the AEP responses to the positive and negative words.

Experimental Question #1

Does the principal components analysis indicate that there are differences in the AEP responses to positively vs. negatively valenced words?

The primary question of the present study, "Can connotative differences be measured in AEPs?" was addressed by performing a PCA using data recorded from the central zenith electrode site only. This location was selected because of its centralized location on the scalp.

For each word presented to a subject, there were 200 AEP voltages recorded and averaged at 10 ms time intervals along the 2000 ms timeline. Brain activity recordings began 100 ms prior to the onset of the stimulus word in order to have a baseline or median activity level for determination of positive and negative waves. The first data point analyzed for the PCA was at 100 ms during the onset of the stimulus word. The last data point analyzed ended at 1860 ms along the timeline, which was well beyond the time when effects due to connotation were expected to occur. Thus, there were 176 time points averaged at 10 ms intervals along the 2000 ms timeline.

The PCA was conducted by factoring data recorded from the individual words. For each of the 15 subjects, there were 10 positively valenced and 10 negatively valenced words presented four

times each. The total analysis was, therefore, based on responses recorded for 1200 total words. These words were used to establish a 1200 (word) x 176 (time points) data input matrix, resulting in 1200 measurements (cases) for each of the 176 time points (variables). The data input matrix was converted to a correlation matrix utilizing the BMDX72 computer program (Dixon, 1972). This program was used to conduct a factor analysis of the data, and the "factors" thus produced identified the component waveforms important to this study.

After the principal factors (components) were identified, the results for the positively and negatively valenced words were separated and an analysis of variance (ANOVA) was performed to determine if there were differences in the AEPs for each factor due to connotation. If connotative effects dominated the AEP responses, one would expect them to be present in those factors that accounted for the largest percentage of subject differences (Factors 1, 2, 3, 4 in declining order of importance). However, if connotative effects were small, then they might only emerge in the higher numbered factors (Factors 5, 6, 7, 8). Results of the ANOVA are included in Table II on the following page.

In the present study, each factor was analyzed to determine whether there were significant differences in the brain's responses to positive and to negative words. The peak components of the

Table II: One-way analysis of variance and covariance for eight factors.

FACTOR	D.F.	SUM OF SQ.	MEAN SQ.	F-VALUE	PROB(TAIL)
1	1	.0844	.0844	.0840	.7723
2	1	.0163	.0163	.0162	.8990
3	1	2.460	2.460	2.481	.1170
4	1	.1156	.1156	.1150	.7349
5	1	21.58	21.58	24.40	.0000
6	1	.0067	.0067	.0066	.9353
7	1	7.681	7.681	7.980	.0053
8	1	9.910	9.910	10.43	.0015

waveform were also examined to ascertain whether they occurred at a significant point in time. There was the expectation that there would be significant AEP events occurring in the time ranges from 100 to 850 ms due to acoustic processing, and from 850 to 1500 ms due to linguistic/semantic/connotative processing. For the early event, it would not be predicted that valence differences would be significant. For the late event, it was determined that differences which occurred at approximately 1256 ms would be considered significant because information obtained through the visual inspection technique suggested that the average response latencies for the positive and negative words for the 15 subjects occurred at that time.

Eight principal components were extracted in this experiment, accounting for 73% of the total variance of the waveforms. The centroid and waveforms for each factor are shown in Figures 1-9. The factors were numbered ordinally--with Factor 1 accounting for the largest amount of the variance explained by the factor and Factor 8 accounting for the least amount of variance explained.

Factor 1 accounted for 22% of the total variance, with the broad peak component occurring at approximately 1450 ms along the time line. This component was located at the outer limits of where a P3 response was anticipated, and there was no differentiation between the positively valenced words and the negatively valenced words. Factor 1, therefore, was not considered to be important in distinguishing connotations. Researchers have not extensively studied the brain's responses to semantic stimuli this far out in time, so it was difficult to interpret the cause or meaning of this particular component.

Factor 2 explained 16% of the variance, and its peak component occurred at approximately 740 ms along the time line. This was prior to the time when a cognitive response to stimulus words was expected, and the positively and negatively valenced words were not differentiated. As a result, this particular component was not considered relevant to the analysis. It was interesting to note, however, that the peak component for this waveform occurred at a point in time where all of the subjects would be analyzing both positive and negative word stimuli acoustically.

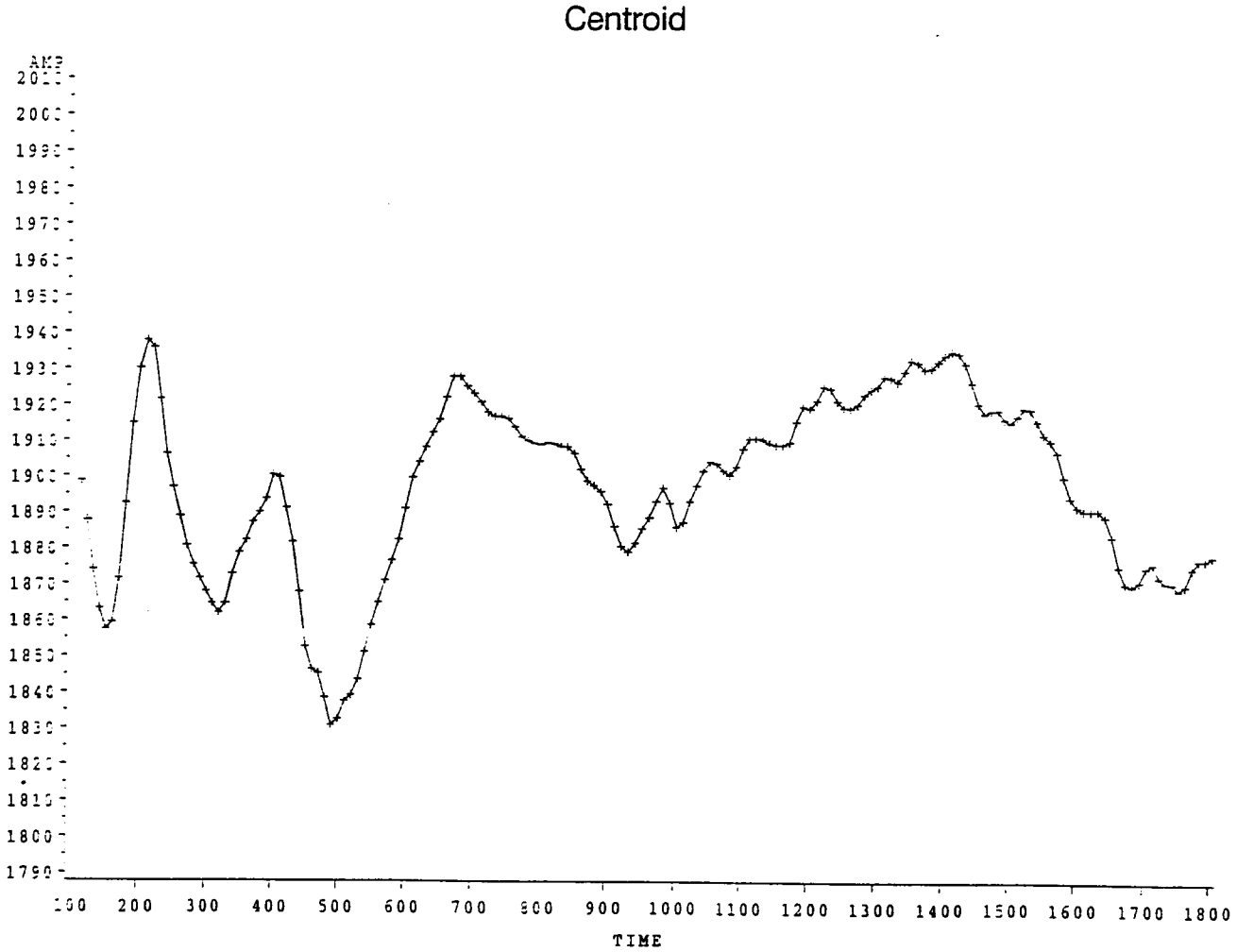


Figure 1: Centroid of eight principal components for 15 subjects (in ms).

At 100K multiplication, approximately 30 numbers represent one microvolt.

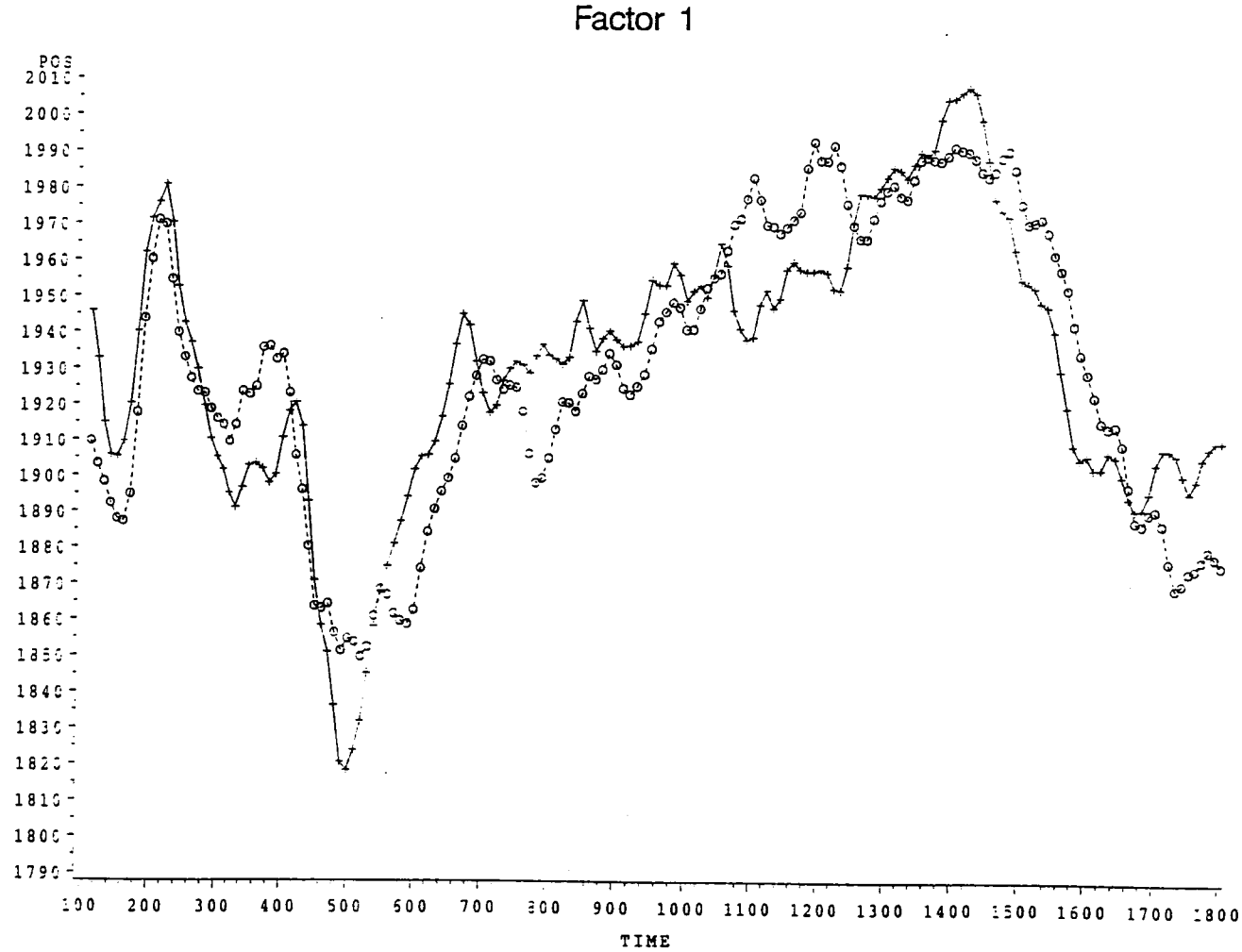


Figure 2: Principal component #1 for positive (+) and negative (o) words for 15 subjects (in ms).

At 100K multiplication, approximately 30 numbers represent one microvolt.

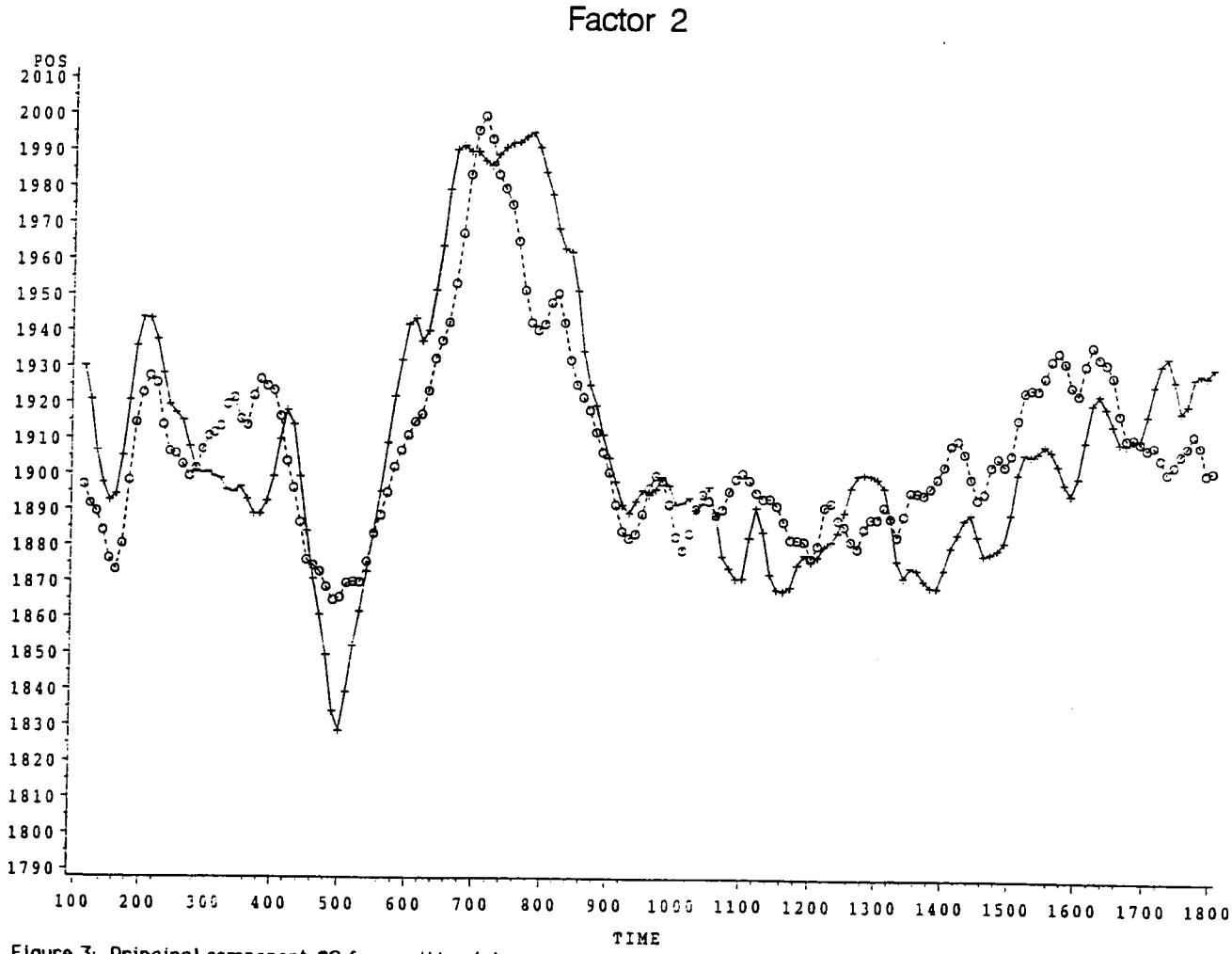


Figure 3: Principal component #2 for positive (+) and negative (o) words for 15 subjects (in ms).

At 100K multiplication, approximately 30 numbers represent one microvolt.

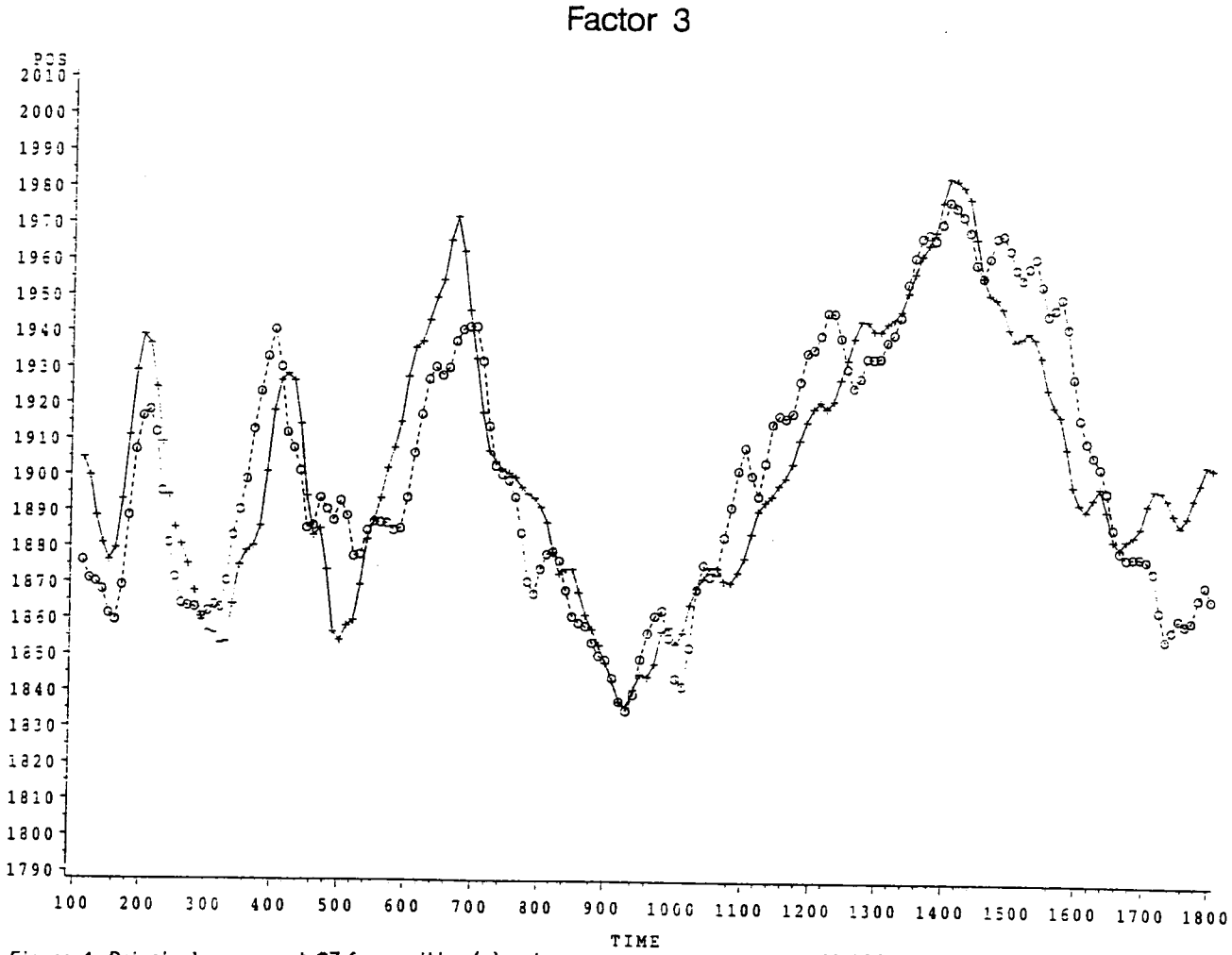


Figure 4: Principal component #3 for positive (+) and negative (o) words for 15 subjects (in ms).

At 100K multiplication, approximately 30 numbers represent one microvolt.

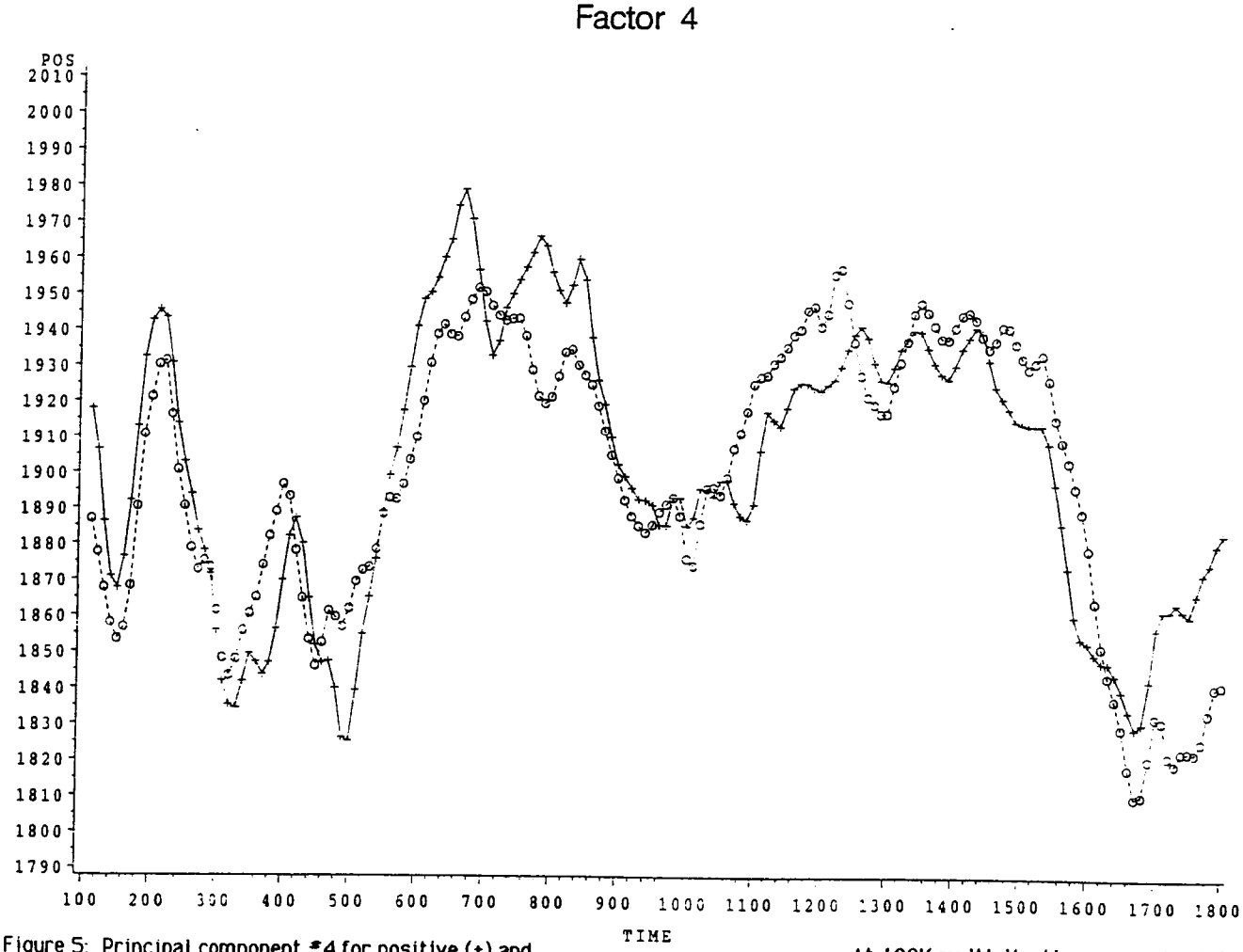


Figure 5: Principal component #4 for positive (+) and negative (o) words for 15 subjects (in ms).

At 100K multiplication, approximately 30 numbers represent one microvolt.

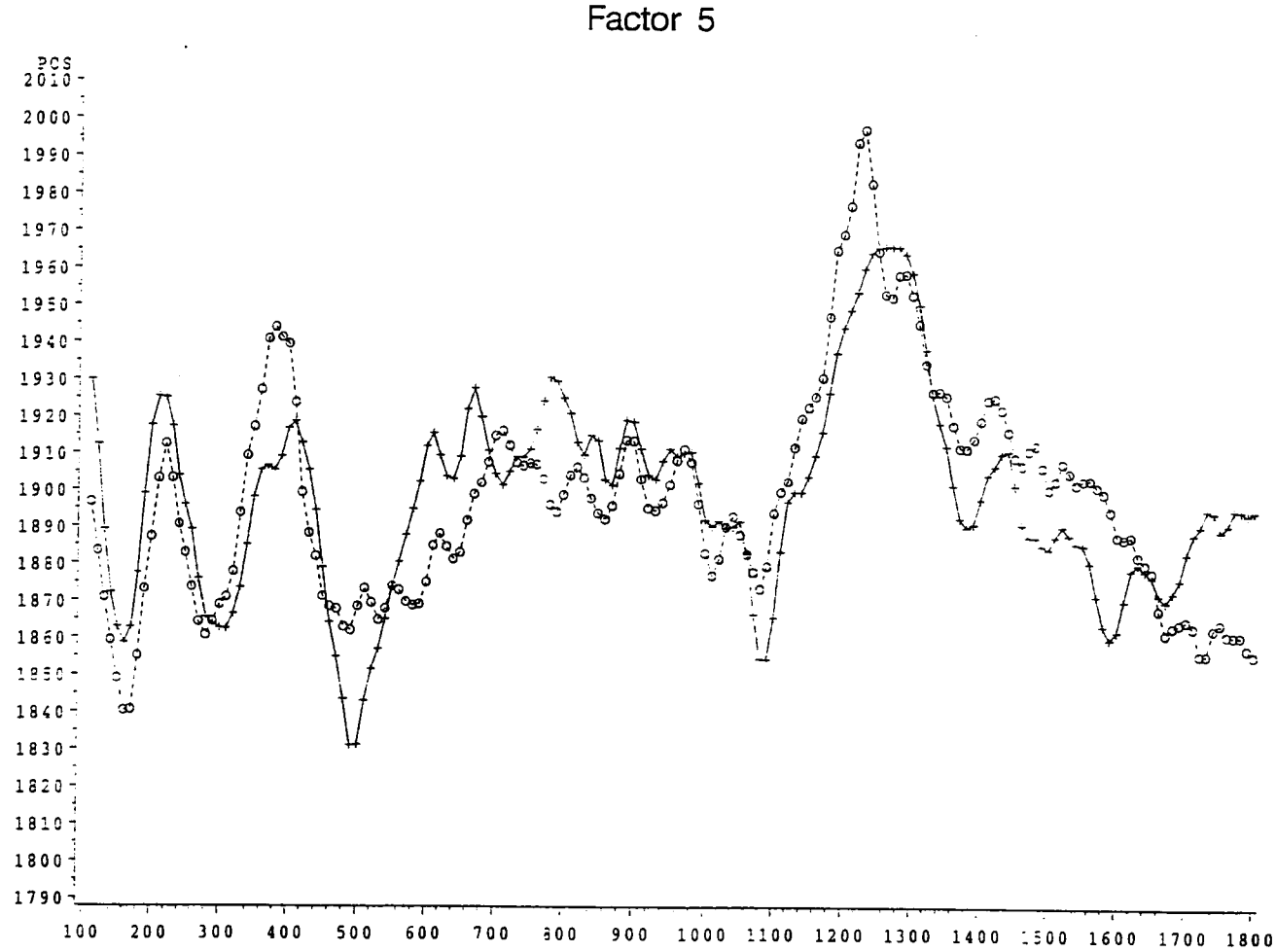


Figure 6: Principal component #5 for positive (+) and negative (o) words for 15 subjects (in ms). Positive and negative words differentiate at arrow.

At 100K multiplication, approximately 30 numbers represent one microvolt.

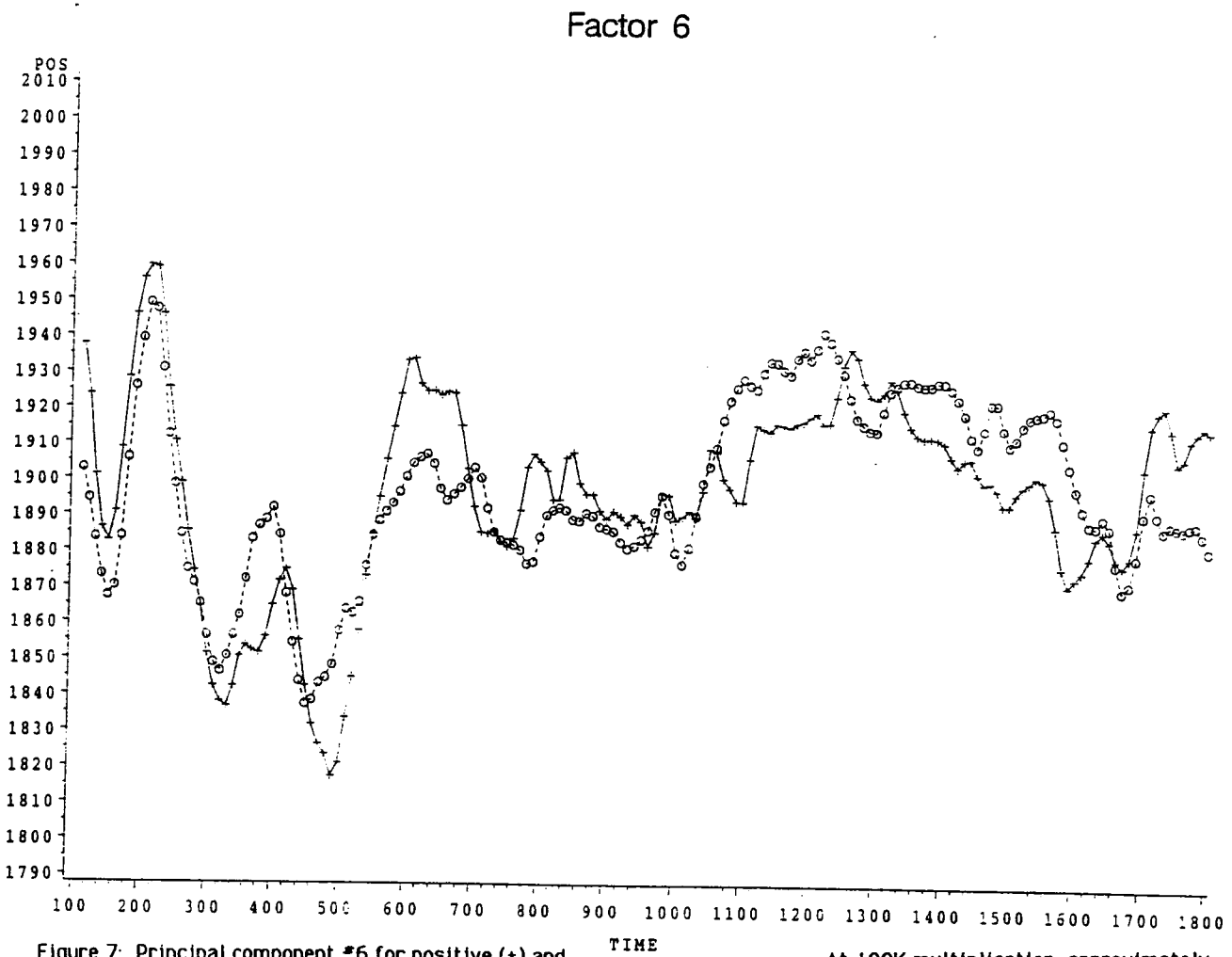


Figure 7: Principal component #6 for positive (+) and negative (o) words for 15 subjects (in ms).

At 100K multiplication, approximately 30 numbers represent one microvolt.

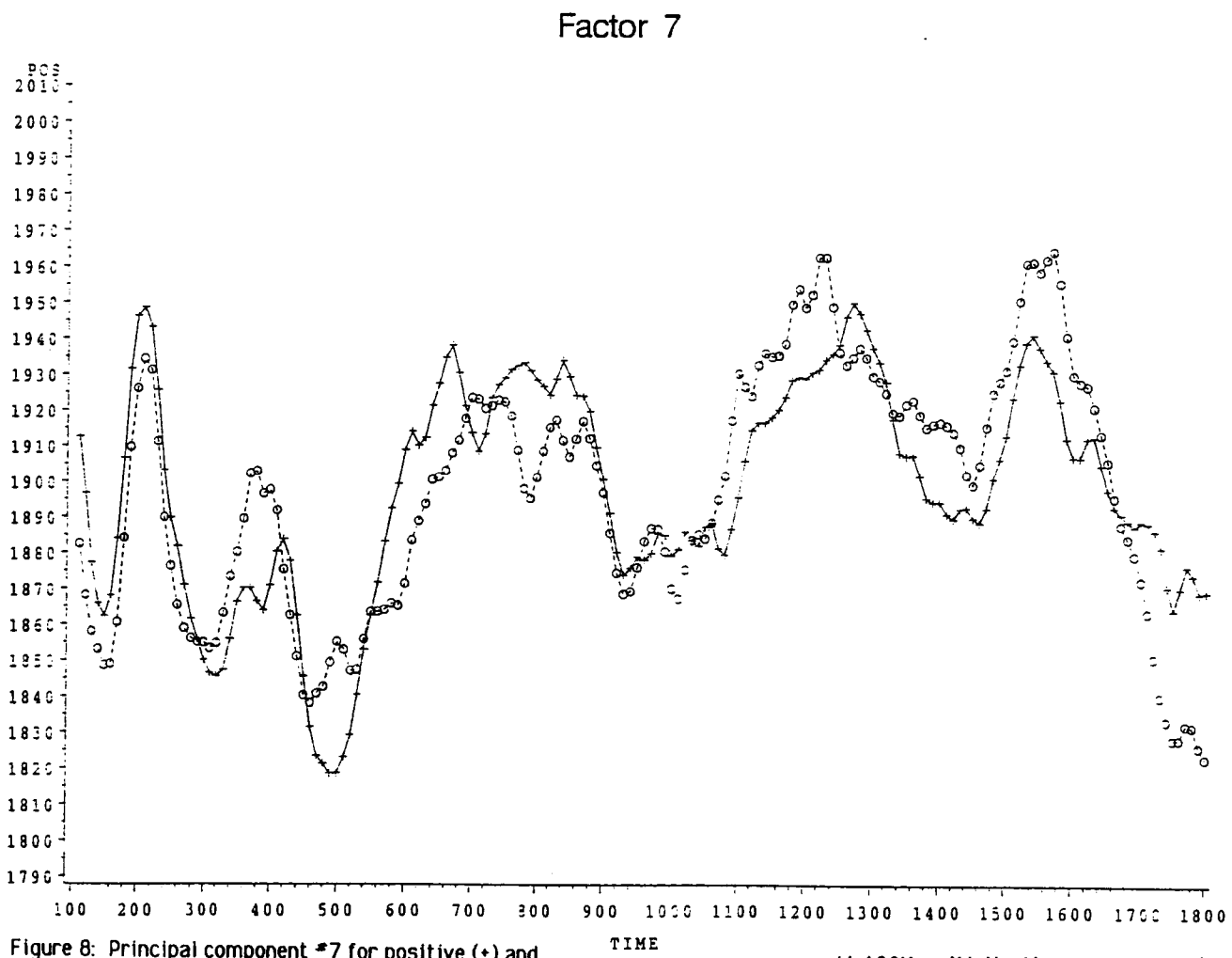


Figure 8: Principal component #7 for positive (+) and negative (o) words for 15 subjects (in ms). Positive and negative words differentiate at arrows.

At 100K multiplication, approximately 30 numbers represent one microvolt.



Figure 9: Principal component #8 for positive (+) and negative (o) words for 15 subjects (in ms). Positive and negative words differentiate at arrow.

At 100K multiplication, approximately 30 numbers represent one microvolt.

Factor 3 accounted for 10% of the variance, and, like Factor 1, it did not distinguish differences in word connotations. Factor 4 accounted for 8% of the total variance, and, like Factor 2, the peak component occurred at 720 ms--prior to where a P3 response was anticipated.

Factor 5 was the first factor which demonstrated a significant variation in the brain's response to the positively and negatively valenced words. This component accounted for 6% of the total variance, and it showed a very high peak amplitude in comparison to the rest of the component waveform. The positively and negatively valenced words were differentiated by the subjects at 1250 ms--a point which correlated well with data obtained in the visual inspection of the waveforms. Therefore, Factor 5 was considered very relevant to the data analysis.

Factors 6, 7, and 8 cumulatively accounted for 11% of the total variance explained. Factor 6 comprised 4% of the total variance, and it was not significant. This factor peaked at approximately 220 ms, only 120 ms after the onset of the stimulus word. The peak component occurred at a time when auditory perception of the stimulus word would be taking place. Factor 7 was more difficult to explain. This factor accounted for 4% of the variance, and it was significant. Peak components occurred at approximately 1220 ms and at approximately 1580 ms. The first component correlated adequately with the visual inspection response latency of 1256 ms, but the second component was beyond the area in which one would expect a P3 response. Factor 8 accounted for 3% of the

variance, and it also was significant. The peak amplitude of this factor occurred at approximately 680 ms. This was prior to the time at which one would expect a P3 response; however, peak amplitudes in the 1220 to 1400 range compare favorably with the average visual inspection latencies of 1256 ms.

II. THE VISUAL INSPECTION TECHNIQUE

The visual inspection technique was used to answer discussion questions #2 through #4. Tables III, IV, and V on pages 71-73 show response amplitudes and latencies for the right (F4) and left (F3) frontal lobes, for the right (P4) and left (P3) parietal lobes, and for the frontal zenith (FZ) and central zenith (CZ) electrode sites.

Experimental Question #2

Is there a difference in the amplitude of the AEP responses to positively vs. negatively valenced words? The answer to this question was determined by comparing positive and negative word amplitudes at each electrode site (see Tables III, IV, and V). Results indicated that 11 of the 15 subjects had higher response amplitudes for the negative words in the right frontal lobe (with two ties) at $p<.025$. Twelve of the 15 subjects

Table III: Positive and negative word latencies and amplitudes for the right hemisphere (F4) and the left hemisphere (F3) by subject.

FRONTAL LOBE DATA

	RIGHT HEMISPHERE (F4)				LEFT HEMISPHERE (F3)			
	LATENCIES		AMPLITUDES*		LATENCIES		AMPLITUDES*	
S*	Pos	Neg	Pos	Neg	Pos	Neg	Pos	Neg
1	1050	1040	1997	1997	1080	1040	1982	1955
2	1130	1220	2067	2050	1200	1180	2058	2103
3	1200	1180	2022	2046	1210	1190	2054	2015
4	1030	1430	2035	2152	1270	1430	2070	2042
5	1400	940	1996	2015	1480	1240	1976	1934
6	1180	950	2022	2028	1000	1020	2015	1974
7	1100	1150	2081	2044	1170	1160	2969	2105
8	1050	1040	1997	1997	1090	1040	1982	1955
9	1210	1210	2099	2158	1350	1500	2128	2066
10	1430	1060	2156	2204	1440	1060	2134	2212
11	1260	1290	2295	2470	1270	1290	2235	2491
12	1030	1060	1967	2014	1060	1070	1920	1952
13	1530	1160	2049	2116	1530	1160	2004	2046
14	1120	940	2159	2163	1130	950	2123	2148
15	970	1310	2160	2202	980	1320	2129	2186
$\bar{X}$	1179	1132	2073	2110	1217	1177	2119	2079

*Numbers for amplitudes are relative numbers. To convert to microvolts, divide the relative amplitude by 30.

Table IV: Positive and negative word response latencies and amplitudes for the right hemisphere (P4) and the left hemisphere (P3) by subject.

PARIETAL LOBE DATA

	RIGHT HEMISPHERE (P4)				LEFT HEMISPHERE (P3)			
	LATENCIES		AMPLITUDES*		LATENCIES		AMPLITUDES*	
S*	Pos	Neg	Pos	Neg	Pos	Neg	Pos	Neg
1	1420	1360	1930	1895	1660	1560	1904	1885
2	1120	1240	2101	2030	1120	1170	1959	1971
3	1470	1260	1989	1964	1190	1260	1935	1954
4	1220	1180	1999	2011	1680	1690	1994	2006
5	1130	1610	2001	2014	1480	1280	1921	1904
6	1160	1350	1969	1905	1560	1350	1923	1950
7	1430	1310	2054	2028	1360	1370	1998	2005
8	1420	1360	1930	1895	1660	1560	1904	1885
9	1340	1630	2063	2002	1330	1490	1983	1988
10	1400	1620	2008	2014	1430	1620	1970	1952
11	1150	1300	2079	2047	1450	1300	1954	2067
12	1320	1580	1949	1935	1410	1030	1892	1873
13	1500	1430	2004	1999	1380	1430	1909	1925
14	1370	950	1999	1963	1370	1440	1981	1948
15	990	1310	1980	1945	1010	1270	1908	1925
$\bar{X}$	1296	1366	2004	1977	1406	1388	1942	1949

*Numbers for amplitudes are relative numbers. To convert to microvolts, divide the relative amplitude by 30.

Table V: Positive and negative word response latencies and amplitudes for frontal zenith (FZ) and central zenith (CZ) by subject.

FRONTAL ZENITH AND CENTRAL ZENITH DATA

	FRONTAL ZENITH (FZ)				CENTRAL ZENITH (CZ)			
	LATENCIES		AMPLITUDES*		LATENCIES		AMPLITUDES*	
S#	Pos	Neg	Pos	Neg	Pos	Neg	Pos	Neg
1	1060	1040	2026	1986	1430	1380	1981	1969
2	1130	1220	2081	2101	1130	1230	2190	2125
3	1200	1190	2028	2055	1470	1190	2070	2058
4	1040	1430	2005	2121	1670	1420	2043	2011
5	1300	1310	1975	1975	1480	1250	1967	1942
6	1190	1030	2058	1948	1080	920	1986	1981
7	1550	1160	2056	2085	1090	1310	2066	2104
8	1060	1040	2026	1986	1430	1380	1981	1969
9	1360	1020	2162	2045	1340	1500	2042	2058
10	1440	1070	2113	2124	1270	1130	2062	1989
11	1270	1290	2303	2437	1150	1290	2051	2242
12	1040	1070	1953	1992	1320	1030	1975	1933
13	1540	1170	2091	2008	1380	1170	1925	2019
14	1120	950	2152	2101	1120	950	2112	2020
15	1320	1320	2103	2155	980	1320	2024	2041
$\bar{X}$	1241	1154	2076	2075	1289	1231	2032	2031

*Numbers for amplitudes are relative numbers. To convert to microvolts, divide the relative amplitude by 30.

also had higher response amplitudes for the positive words in the right parietal lobe at $p<.025$.

Experimental Question #3

Is there a difference in the latency of the AEP responses to positively vs. negatively valenced words? Positive and negative word response latencies were compared at each electrode site to answer this question. Results indicated that there were no significant differences in response latencies between the positive and negative words (see Tables III, IV, and V).

Experimental Question #4

Is there a difference in the laterality of the AEP responses to positively vs. negatively valenced words? To answer this question relative to laterality of response, F3 and P3 were compared with the F4, P4 locations. Results indicated that right frontal (F4) showed greater amplitude of response than F3 for positive words for 12 of the 15 subjects ($p<.025$), but no significant differences were found between F3 and F4 for negative words. There was, however, a definite trend for the

negative words to show a higher amplitude of response in the right frontal lobe (F4), as 11 of the 15 subjects had higher amplitudes at F4 (see Table III). For the two parietal locations (see Table IV), amplitudes for positive words were greater ($p<.001$) at P4 than at P3 (for all 15 subjects), as were the amplitudes for negative words (for 13 of the 15 subjects: $p<.05$).

Positive and negative word response latencies then were compared at F3 and P3 vs. F4 and P4 locations. Results indicated greater response latencies in the left frontal lobe for 13 of the 15 subjects ($p<.001$) for positive words. Eight of nine subjects (six ties) had greater response latencies for the negative words ($p<.025$). No significant differences were observed in parietal lobe response latencies.

CHAPTER V

DISCUSSION

I. SUMMARY OF RESULTS

An analysis of the study results revealed that there was a greater activation of right hemisphere response in the frontal and parietal lobes for both the positive and the negative words. Response latencies were also of greater duration in the left hemisphere of the brain. Results of whether the brain can distinguish positive words from negative words were mixed.

II. EXPERIMENTAL QUESTIONS

Experimental Question #1

Eight components were extracted in this experiment, accounting for 73% of the total variance of the waveforms. A one-way ANOVA indicated that AEP responses to the positive and negative words differed significantly for three of the eight principal components. These included Factors 5, 7, and 8. Factors 1, 2, 3, 4, and 6 were not significant. These waveforms may be viewed in the Results section.

The variance explained by Factor 5 was 6%, and the peak

amplitudes of the positive and negative word waveforms differentiated significantly at a time point of approximately 1250 ms. The total variance explained by Factor 7 was 4%, and the waveform for this component also differentiated significantly at approximately 1220 ms along the timeline. These results suggested that both factors 5 and 7 distinguished between the waveforms for the positive and negative words at approximately the 1250 ms time point. These factors peaked at approximately 650 ms after the offset of the stimulus word. Response durations concurred with the average response latencies of 1256 ms observed during visual inspection of the waveforms, and provided corroborating evidence for the accuracy of the visual analysis since, "the peaks of many of these components do not occur at the same time points as the positive and negative peaks of the observed EPs" (Chapman et al., 1980, p. 91). Caplan (1987) further explained that the principal components analysis probably more accurately reflects "the entirety of the cerebral processes which are responsible for the waveform" (p. 412) since the measurement of the largest positive amplitudes following the presentation of the stimulus "may be an arbitrary measurement" (p. 412).

Factor 8 differentiated between the positively and negatively valenced words at a time point of approximately 680 ms. This factor accounted for 3% of the total variance, and its functional

significance was uncertain. Since this component peaked at only 180 ms following the offset of the stimulus word presentations, its temporal location was prior to the time at which a P3 response was anticipated. Based on its early temporal location, it may be related to the acoustical analysis of the stimuli, to individual differences among the subjects, or to arousal following the stimulus presentation.

Experimental Question #2

There was a significant difference in response amplitudes in the right frontal lobe, with the negative words having the higher amplitudes. There was also a significant difference in response amplitudes in the right parietal lobe, with the positive words having the higher amplitudes.

It may not be possible to ascertain exactly why the words with negative connotations demonstrated a higher average peak amplitude in the right frontal lobe, and words with positive connotations demonstrated a higher average peak amplitude in the right parietal lobe. However, there is a plausible explanation as to why the right hemisphere electrode sites might be more sensitive to word connotation discrimination than the left hemisphere.

Chernigovskaya, Balanov, and Devlin (1983) conducted an

interesting study with bilingual subjects in which they used electroconvulsive shock treatments to unilaterally suppress language in the stimulated hemisphere. By asking the subjects to perform various linguistic skills tasks utilizing both their native language (L1) and their acquired language (L2), they arrived at the following conclusions:

1) the left hemisphere was responsible for the formation of surface structures in both languages;

2) the left hemisphere also was responsible for the formation of second language deep structures; and

3) the right hemisphere was concerned with the formation of deep semantic structures of the native language.

If the results of the Chernigovskaya et al. (1983) experiment were accurate, and the right hemisphere of the brain is responsible for the formation of linguistic deep structures (i.e. linguistic meaning) in L1 of polyglots, then it also is plausible that this hemisphere is more discriminating than the left when confronted with a task requiring discernment of word connotations. Additional information supplementing this idea is discussed in the response to Experimental Question #4.

Experimental Question #3

No significant differences were found in response latencies for the two different word types. It may be assumed, therefore, that if each respective hemisphere performs the same tasks when discriminating among positive and negative word connotations, then response latencies should be similar for both when these latencies are compared by hemisphere.

Experimental Question #4

Results indicated that there was a significant difference for positive word latencies between left and right frontal lobes ($p<.001$), with greater response latencies occuring in the left frontal lobe. There also was a significant difference for positive word response amplitudes between left and right frontal lobes ($p<.025$), with a greater response amplitude in the right frontal lobe. Words with negative connotations had greater response latencies in the left frontal lobe ($p<.025$), but significant differences were not found for response amplitudes, although 11 of the 15 subjects had higher response amplitudes in the right frontal lobe.

Amplitude peak latencies identified by visual inspection for the left and right parietal lobes did not differ when the chi-square test

was applied to the data. However, there were significant differences in response amplitudes for both positive ($p<.001$) and negative ($p<.005$) words, with the right parietal lobe demonstrating the higher amplitude of response for each.

These results, again, were consistent with the theory postulated in the discussion of Experimental Question #2, or the idea that the right frontal lobe of the brain may be partially responsible for distinguishing among various word connotations. This hypothesis might explain why response latencies were of greater duration in the left frontal lobe, as well.

Umphred (1995) reported that the frontal lobes "are involved in short-term (i.e., "working") memory, attention, and response inhibition, all of which are important for cognitive functioning" (p. 61). If the right hemisphere of the brain is, in part, responsible for maintaining attention and for "sorting through" word connotations to determine word meaning, then it is possible that the greater response latencies result from having to "await" the completion of this process before a cognitive response is initiated in the left hemisphere. If, as Chernigovskaya et al. (1983) suggested, the right brain is responsible for deep linguistic structures, then this also explains the greater response amplitudes for positive words in the right frontal lobe.

In an experiment designed to study the language and speech

capacity of the right hemisphere in brain-bisected patients, Gazzaniga and Hillyard (1971) found that the right hemisphere had little or no syntactic capacity. They also failed to confirm that the right hemisphere initiated speech on its own. However, when visual stimuli were projected to the right or left hemispheres of subjects and they were asked to verbally identify what they saw, they found that the right hemisphere was significantly more adept at responding to this information. The authors hypothesized that the left hemisphere's response delay might be the result of "interhemispheric cross-cueing, whereby the right hemisphere performs the two choice discrimination and sends an 'either-or' recognition pulse (either subcortically or extracranially) to the left hemisphere. The additional time required for recognition of the transferred 'pulse' could easily fit within 175-200 ms" (p. 278). If the same sort of discrimination-recognition system is utilized to distinguish among word connotations, then this could explain the longer left hemisphere response latencies found in this experiment.

While left hemispheric lesions are more likely to cause interference with verbal activity, they are less likely to cause nonverbal perceptual and cognitive deficits than are similar lesions of the right hemisphere (Milner, 1962; Weinstein, 1962; Lenneberg, 1967). Lenneberg (1967) also suggested that language "is probably due to the peculiar way in which the various parts of the brain work

together or, in other words, to its peculiar function" (p. 72).

Wexler, Warrenburg, Schwartz, and Janer (1992) studied EEG and EMG responses to emotion-evoking stimuli using fused dichotic auditory stimuli consisting of emotionally neutral words paired with either positive or negative words. The authors recorded EEG alpha activity as baseline reference over the left and right frontal lobes. They found greater right vs. left hemisphere brain activation when the emotion-evoking stimuli were processed without conscious awareness by the subjects.

In a study which involved electrical stimulation applied to the right hemisphere of left hemisphere dominant subjects undergoing temporal lobe resection for seizures, Andy and Bhatnagar (1984) theorized that the "right nondominant hemisphere normally possesses latent language functions" which under certain conditions "become functional and thus measureable" (p. 164). They found that when a short, abrupt electrical current was applied to certain areas of the right hemisphere, and patients were asked to perform language (naming) tasks, speech arrests, distortions, misnamings, syllable repetitions, omissions, and slowing of speech occurred. Application of the electrical current to the right parietal lobe also caused misnaming and omission of words, in addition to the other difficulties, thereby indicating that the right parietal lobe has the

capacity for semantic processing, as well as for other speech and language functions.

In another study, Kertesz, Sheppard, and MacKenzie (1982) stated that the posterior association area of the parietal lobes may play an important role in semantic processing. The present study supported their findings in that amplitude differences for positive and negative words were found in the parietal lobes, with the right parietal lobe evoking the higher response amplitudes.

III. FURTHER RESEARCH

The results of this experiment suggested that it may be possible to distinguish word connotations through AEPs. Molfese (1985) stated the following: "At this time, at least, it would appear that the AFR as represented in the present study is sensitive to differences in semantic features rather than to the emotional impact of the words" (p. 296). Additional research is required to either prove, or disprove, his conclusion. Words with very high positive and/or negative valences (such as the stimuli utilized in this study) should be compared with low valenced words (words with values between +1 and -1 on the semantic differential scale) to see whether they are differentiated through AEPs. This experiment would answer questions regarding his hypothesis that

connotations are not measured through AEPs, but, rather, that meaning as a function of semantic features accounts for differences in AEP values.

Connotations research might be conducted using male subjects to see if their responses are similar to those revealed by females in the present study. Other experiments also might include subjects from various cultural backgrounds to study their responses to the word stimuli. Information obtained through such inquiries undoubtedly will lead researchers to ask many additional questions which add to the AEP knowledge base.

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APPENDICES

APPENDIX A

THE OLDHAM HANDEDNESS TEST

Oldfield, R.C. (1971) The assessment and analysis of handedness: The Edinburgh inventory. Neuropsychologia, 9, 97-113.

R. C. Oldfield

APPENDIX II

Medical Research Council Speech & Communication Unit

EDINBURGH HANDEDNESS INVENTORY

Surname_____ Given Names_____

Date of Birth_____ Sex_____

Please indicate your preferences in the use of hands in the following activities *by putting + in the appropriate column.* Where the preference is so strong that you would never try to use the other hand unless absolutely forced to, *put ++.* If in any case you are really indifferent *put + in both columns.*

Some of the activities require both hands. In these cases the part of the task, or object, for which hand preference is wanted is indicated in brackets.

Please try to answer all the questions, and only leave a blank if you have no experience at all of the object or task.

		LEFT	RIGHT
1	Writing		
2	Drawing		
3	Throwing		
4	Scissors		
5	Toothbrush		
6	Knife (without fork)		
7	Spoon		
8	Broom (upper hand)		
9	Striking Match (match)		
10	Opening box (lid)		
i	Which foot do you prefer to kick with?		
ii	Which eye do you use when using only one?		

L.Q.		Leave these spaces blank	DECILE	

APPENDIX B

THE 10-20 SYSTEM

APPENDIX B

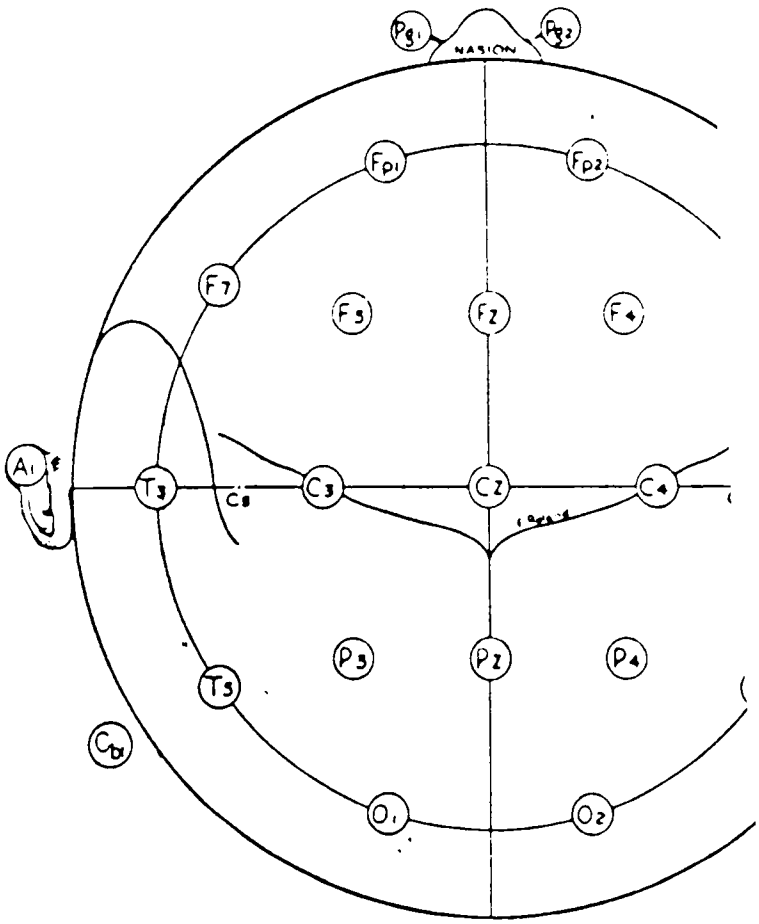
THE 10-20 SYSTEM

Before the early AEP researchers could compare and contrast data from their studies, a standardized method of electrode placement on the scalp was needed. Jasper (1958) headed a committee which developed a system to fulfill this need. In the 10-20 System, the "10" refers to reference points located 10 percent of the distance between the naison and inion anterior-posteriorally, and 10 percent of the distance between the pre-auricular areas laterally. These scalp regions provide useful reference points for electrode placement. The "20" refers to the placement of electrodes on the region of the scalp which corresponds to a distance 20 percent above the "10" markings. Electrodes placed on the right side of the scalp are assigned an even number, and electrodes on the left side are assigned an odd number. Each electrode is also assigned a letter which corresponds to the lobe of the brain located beneath the scalp electrode, including the frontal zenith, the parietal zenith, and the central zenith (located at the scalp midline).

To place electrodes, the skin at marked locations is roughened mildly with an astringent paste. An adhesive paste

is then placed on the electrode, and it is affixed to the scalp and secured with tape. A total of 21 standard electrode placement sites may be used with the 10-20 System.

Figure 10: The 10-20 System (Jasper, 1958).



VITA

Steven J. Cloud was born in Connersville, Indiana, on January 24, 1960. He graduated from his high school class as salutatorian in 1978, and he attended The University of North Carolina at Chapel Hill for two years before transferring to Western Carolina University. He graduated Summa Cum Laude from Western with a B.S. Ed. and a major in Communication Disorders in 1982. Cloud spent one year teaching fourth and fifth grade Language Arts and Social Studies in San Jose, Costa Rica, before pursuing a Master's Degree in Communication Disorders at the University of South Carolina. He graduated from this program with High Honors in 1985, and he worked for Southeastern Speech and Hearing Services in Fayetteville, NC, for one year. Cloud then moved to Florence, SC, where he served as a clinician and the Director of Speech Pathology for HealthSouth Rehabilitation Corporation. He left the job in Florence in August 1988, to pursue a Ph.D. in Audiology and Speech Pathology at the University of Tennessee. While attending graduate school, Cloud worked as a clinical supervisor at the U.T. Hearing and Speech Center. He also taught undergraduate and graduate courses in Multicultural Language Issues, and he worked as a home health speech-language pathologist for a private practice. He received his doctorate in May, 1997.

Cloud currently teaches courses in stuttering, language development, aphasia, dysphagia, multicultural language issues, anatomy and physiology, and traumatic brain injury at the University of Southern Mississippi in Hattiesburg.