THE EFFECTS OF MUSIC RELAXATION TRAINING ON BRAINWAVE ACTIVITY

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To the Dean for Graduate Studies and Research:

I am submitting herewith a dissertation written by Kimberly S. Heft entitled "The Effects of Music Relaxation Training on Brainwave Activity." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Music Therapy.

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THE EFFECTS OF MUSIC RELAXATION TRAINING
ON BRAINWAVE ACTIVITY

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Abstract

The effect of music relaxation training on brainwave activity was measured using two right handed females as subjects. Experimental conditions of (a) silence, (b) sedative music, and (c) stimulative music were presented before and after an intensive two week music relaxation training period. Brainwave activity was measured and examined relative to peak microvoltage and activity within frequency bands. The purpose of this study was to determine whether or not music relaxation training can affect brainwave activity under silence and contrasting music conditions.

Pre and post readings were compared to data base norms accessible in the Bio-logic Brain Atlas computer program. No significant cycle to cycle deviations were found. Microvoltage means were calculated to perform matched t-tests on the two frequency bands of delta and alpha using BMDP Statistical Software. No significant differences were found among the change scores of the microvoltage means for each of the three conditions.

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CHAPTER I

INTRODUCTION

Technical developments of the past two decades have enabled researchers to examine human physiological responses in a manner that previously had not been feasible. With the development and refinement of the electroencephalogram (EEG), electromyogram (EMG), galvanic skin response (GSR), and other physiological measures, exploration and measurement of biological responses to the human experience is now even more possible and feasible.

With these advances, research in the area musical perception and response abounds with possibilities. We have essentially reached a point in time in which quantitative biologic measurement of an aesthetic experience is feasible. Interpretation of such measures will probably always have limitations, but if handled with care and discretion, measurement of biological responses can contribute to a better understanding of the human response to music.

The issue being addressed in this study is one of perception of musical stimuli and the biological response to that perception. Broken down, factors of auditory perception fall into the categories of (a) physical reception of sound, (b) neurological interpretation of the acoustical information, and (c) the emotional response to the musical message. Although these areas are deeply intertwined and connected, the primary focus of this study addressed the physiological reception and interpretation of musical stimuli. The effect of music relaxation training on brainwave activity was measured under silence and contrasting music conditions. Experimental conditions of (a) silence, (b) sedative music, and (c) stimulative music were presented before and after an intensive two week relaxation training period. Brainwave activity was measured and examined relative to microvoltage strength and activity within frequency bands. The purpose of this study was to determine whether or not music relaxation training can affect brainwave activity under silence and contrasting music conditions.

CHAPTER II

REVIEW OF LITERATURE

In the examination of brainwave response to musical stimuli, it is important to keep in mind a unique characteristic of the human nervous system. Each cerebral hemisphere receives biologic messages from the opposite side of the body. Visual, motor, and tactual information received from the right is processed by the left half of the brain, and visa versa. This characteristic also holds true in the functioning of the auditory system. The brain receives input from both ears, but the crossed connections are much stronger than the uncrossed ones.

It has been commonly suggested that the right cerebral hemisphere plays a dominant role in the processing of musical sounds. However, what has been found in research indicates the existence of a much greater degree of functional discrimination of information. This literature review will summarize and highlight the developments of brainwave/music research, and focus upon points relevant to the present study.

Early studies served to distinguish hemispheric functioning, particularly with respect to processing speech and nonspeech sounds. Milner (1962) tested patients with the Seashore Measurement of Musical Talent after temporal lobectomies were done for epilepsy. She discovered that timbre and tonal memory were impaired in those patients with right temporal lobectomies, but not so much by those with left temporal lobectomies. These findings suggested that tonal perception depended more on right temporal activity. Milner also noted that rhythmic elements seemed to be less hemispherically specialized.

Kimura (1964) experimented with two auditory tests consisting of dichotically presented melodies and spoken digits. The results demonstrated that the right hemisphere processed the melodies more efficiently than the left. This study was significant in that it used "normal" subjects rather than patients, and used repeated measures of the same subjects. Kimura (1967) achieved a similar conclusion in a study in which subjects demonstrated superior recognition for words received in the right ear and superior identification of melodies being received in the left ear.

In a replicating study, Shankweiler (1966) confirmed Kimura's conclusions that verbal/nonverbal perceptual distinction of the two temporal lobes indeed existed, and that the right hemisphere functionally dominated in the role of music perception. It is important to note, however, that Shankweiler suggested that the dominance effect for music was not necessarily the same as the dominance effect for language. It was found that since language dominance was overall of a higher level, it could sometimes resist the impact of the lesions, whereas the dominance for musical ability could not.

By the 1970s it was becoming evident that the processing of musical sound was much more complex and dependent on individual characteristics. Studies began to focus more on functional brain tasks rather than generalized hemispheric dominance. During this decade the evolution of knowledge and technology allowed for more elementary and detailed research.

Gordon (1970) devised a study that basically was designed to question previous conclusions that generalized verbal mediation to the left hemisphere and spatially-oriented or non-verbal forms of perception to the right. Two tests were devised that separated timbre and chordal qualities from the melodic and rhythmic aspects of music. Less of a generalized dominance in musical perception was observed in the right hemisphere when music was divided into more distinct elemental forms.

A study done by McKee, Humphreys, and McAdam (1973) examined the alpha activity particularly over temporal-parietal sites while subjects were engaged in a musical task or in linguistic tasks of varying difficulty. Alpha ratios were found to be highest for the musical task and to decrease progressively with increasing difficulty of the linguistic tasks.

To further explore functional lateralization of music and speech processing, Bogen and Gordon (1971) and Gordon and Bogen (1974) injected patients with sodium amobarbital. When chemically depressed, the left hemisphere maintained verbal function, but was unable to elicit singing. When the right hemisphere was depressed by the intracarotid amobarbital, speech ability was disturbed minimally, while the musical function was maintained. Gordon and Bogen (1974) also reported that rhythm was not affected during the left hemispheric depression. As noted earlier, Milner (1962) and Gordon (1970) also observed a lack of hemispheric specialization of rhythmic aspects of music.

Bever and Chiarello (1974) examined cerebral dominance in musicians and nonmusicians. This important study disputed the generalization that speech activity occurred predominantly in the left hemisphere and that the right hemisphere was specialized for many of the nonlinguistic functions. This study was a leader in differentiating types of musical perceptions and suggesting the hypothesis that the left hemisphere dominates analytic processing and the right hemisphere is active in more holistically or spatially oriented processing. This hypothesis was supported by other studies conducted by Davidson and Schwartz (1977), Gates and Bradshaw (1977), Johnson (1977), and Shannon (1980).

Gordon (1978) looked at left hemispheric dominance using rhythmic and pitch elements in dichotically presented melodies. Results of his study postulated that the hemispheric dominance is governed not so much by the type of stimuli as it is by the cognitive function required by the left and right hemispheres to process the stimuli.

Walker (1980) investigated interhemispheric differences in alpha, theta, and delta activity during a music recognition task. No significant hemisphere lateralization or ear effects were found. These results suggested that during a melodic recognition task, alpha activity at the occipital sites is directly related to an information processing task.

A study that measured the auditory perception of music by topographic brain mapping (Breitling et al., 1987), examined right handed normal subjects. Musical material was broken down into a single note, a scale, and a melody. The results of this study revealed a predominance of left midtemporal electrical activity for the note and scale conditions, and a predominance of right midtemporal and frontal electrical activity for the melody.

Researchers in the area of music therapy seem to have focused primarily on alpha brainwave production (8 to 12 Hz.) because these rhythms typically accompany a state of tranquil alertness and calmness of mind. Some studies have shown that under these conditions learning is more effective and productive (Borling, 1981; Wagner & Menzel, 1977). Alpha wave production in musicians and nonmusicians has been examined in several studies (Wagner, 1975; Wagner & Menzel, 1977; McElwain, 1974, 1979). Consistent findings in these experiments reveal that musicians characteristically produce overall higher levels of alpha rhythms than nonmusicians.

McElwain (1974) postulated that the difference between the alpha production in musicians and nonmusicians was the results of the subjects' like or dislike for the music chosen. Subjects were asked to choose their favorite music as part of the experimental design. The results of this study confirmed musician and nonmusician alpha production differences. The results also disclosed alpha production differences between music chosen by the examiner and subject, and music categorized as sedative and stimulative.

Wagner (1975) compared musician and nonmusician brainwave production while the subjects passively listened to music. Two contrasting musical stimuli and silence were presented under no-feedback and alpha-feedback conditions.

Findings indicated musicians produced nearly one third more alpha than nonmusicians during the listening sessions. From the results of this study Wagner postulated that previous musical learning and attentiveness to music could be causal factors for the increased alpha production.

In a study designed to measure the effect of music listening and attentiveness training on musicians and nonmusicians (Wagner & Menzel, 1977), nine musicians and nine nonmusicians were randomly assigned to three experimental groups. Subjects in a distraction group listening to 40 prerecorded music lessons were instructed to tally each time their attention wandered from the listening. Another group listened to the same 40 lessons, but subjectively rated their attentiveness. A no contact control group did no assigned listening. The distraction group reduced their mean number of distractions from 50 to 17.5 during the 40th session. The listening group reported no gain in attentiveness measures. The musician population showed an increased and significantly higher alpha wave production during the EEG pre, mid, and post monitoring, and fell asleep during testing significantly less than did nonmusicians.

Walker (1977) examined correlations between the EEG frequency measures and subject's reactions to music. Self reports of attentiveness, emotional reactions, and familiarity with the music correlated moderately to significantly with EEG frequency measures.

In an experiment that monitored brainwave production of children (Furman, 1978), the effects of two musical stimuli and silence were measured by monitoring the temporal lobes of 30 children. This replicated the study Wagner conducted with adults. The experiment also investigated the effects of music with text (a children's story), music alone, and text alone, on temporal lobe alpha production during the silence condition, with no significant difference evident between the two aural conditions. Other comparisons revealed no significant difference between age groups in the total number of seconds spent in alpha, but did find a significant correlation between age group and aural conditions. The results of the second part of the study revealed no significant difference in alphawave production between the three different presentations of the story.

McElwain (1979) investigated the effects of spontaneous and analytical music listening on right and left temporal lobes of 50 musicians and 50 nonmusicians. Alpha wave production was found to be significantly higher in the left hemisphere for musicians and higher in the right hemisphere for nonmusicians.

The effects of sedative and stimulative music on the ability of high-creative and low-creative subjects to focus attention (Borling, 1981) was systematically examined. No significant difference was again found in the alpha production between the sedative and stimulative music, and creativity was found to play no significant role in the ability to focus attention.

In summary, results of the survey of the literature suggest the following:

1. Although there is a general tendency for the right hemisphere to process musical sounds, the functional lateralization is ultimately determined by the listener's interest, skills, and relationship to the stimuli.

2. Musicians show a general tendency to produce more alpha than nonmusicians.

3. Musicians tend to listen to music more analytically than nonmusicians.

CHAPTER III

METHOD

Statement of the Problem

This study was essentially divided into two parts. The first part compared the subjects' responses to the three experimental conditions of silence, sedative, and stimulative music to the data base norms already established by Bio-logic. The following null hypotheses were tested:

Null Hypothesis 1: There will be no significant cycle to cycle differences in brainwave activity, between the Bio-logic data base norms and the silence experimental listening condition, before music relaxation training.

Null Hypothesis 2: There will be no significant cycle to cycle differences in brainwave activity, between Bio-logic data base norms and the sedative music experimental listening condition, before music relaxation training.

Null Hypothesis 3: There will be no significant cycle to cycle differences in brainwave activity, between Bio-logic data base norms and the stimulative music experimental listening condition, before music relaxation training.

Null Hypothesis 4: There will be no significant cycle to cycle differences in brainwave activity between Bio-logic data base norms and the silence experimental listening condition, after music relaxation training.

Null Hypothesis 5: There will be no significant cycle to cycle differences in brainwave activity between Bio-logic data base norms and the sedative music experimental listening condition, after music relaxation training.

Null Hypothesis 6: There will be no significant cycle to cycle differences in brainwave activity between Bio-logic data base norms and the stimulative music experimental listening condition, after music relaxation training.

The second part of the study compared differences between the three experimental conditions of silence, sedative music, and stimulative music for the frequency bands of delta and alpha. The following null hypotheses were tested:

Null Hypothesis 7: There will be no significant difference in delta brainwave production between the silence and sedative experimental conditions.

Null Hypothesis 8: There will be no significant difference in delta brainwave production between the silence and stimulative experimental conditions.

Null Hypothesis 9: There will be no significant difference in delta brainwave production between the sedative and stimulative experimental conditions.

Null Hypothesis 10: There will be no significant increase in alpha brainwave production between the silence and sedative experimental conditions.

Null Hypothesis 11: There will be no significant increase in alpha brainwave production between the silence and stimulative experimental conditions.

Null Hypothesis 12: There will be no significant increase in alpha brainwave production between the sedative and stimulative experimental conditions.

Study Design

The structure of the study was a pre-test/post-test repeated measure design with two experimental conditions and a control.

Dependent variable: Electrical brainwave production

1. Pre-training brainwave production was compared to Bio-logic control files.

2. Post-training brainwave production was compared to Bio-logic control files.

3. Brainwave production differences were measured between the silence, sedative music, and stimulative music.

Independent Variables:

1. Experimental conditions were silence, sedative music, and stimulative music.

2. Music relaxation training served as an intervening variable.

Subjects

Two right handed female college students, ages 22 and 23 years, were subjects for this study. Neither had extensive musical training and indicated an aversion toward "heavy metal" rock music.

Apparatus

A Bio-logic Brain Atlas III System (Version 2.311, Model 172) at the University of North Texas Center For Research on Learning and Cognition was used for collection and analysis of the EEG data. The Brain Atlas III is a computerized data collection and analysis system which contains subsystems that amplify, filter, and digitize the EEG signal. These digitized values are analyzed through an algorithm that separates the complex signal into waveform bands of delta, theta, alpha, and beta. This process of signal separation is called the Fast Fourier Transform (FFT) and results in a single amplitude value for each electrode site at each .5 Hz. frequency point (see Appendix D).

Twenty-one scalp electrodes were applied according to the International Ten-Twenty System of Electrode Placement. Omni EEG Skin prepping paste was used as a skin abrasive, and Ten-20 Conductive EEG Paste was used for adherence. A portable Sony CFS-W303 stereo cassette player produced the music stimuli, and three to four minutes of the following selections were recorded for the music stimuli:

Sedative music: George Winston piano solo, "Thanksgiving."

Stimulative music: Yngwie J. Malmsteen, heavy metal guitar, "Krakatau."

Procedure

The subjects were seated in a comfortable chair during the procedure. Each subject's head was measured following the International Ten-Twenty System of Electrode Placement, and marked using a red non-toxic skin marking pencil. Once marked, each point was scrubbed with an EEG skin abrasion paste. Electrodes were then applied using EEG paste designed for conduction and adherence. Impedance levels were carefully calibrated and kept below 3K ohms and within 2K ohms between electrode sites. The light in the room was lowered, and baseline data were collected following EEG protocol of eyes opened and eyes closed for 3 minutes. Then with the eyes closed, EEG readings were collected on 3 minutes of silence, 3-4 minutes of sedative music stimulus, and 3-4 minutes of stimulative music. Before each experimental condition, the subjects were asked to mentally process and verbally answer several simple math problems that were dictated to them. Procedures followed for the pre and post measurements were identical.

Music Relaxation Training Procedures:

Between the pre and post readings, six 30 minute sessions of music relaxation training were conducted over a 2-3 week period. Tapes and instruction for home practice were provided. Seated in a comfortable recliner, subjects were first oriented to the procedures. Then a progressive relaxation induction with musical background was presented for 10 minutes, followed by a 5-8 minute period of an open guided imagery. A period of discussion and reflection on the experience ended each session. The following music was used during the relaxation progressions:

Harold Budd - White Arcade

Brian Eno - Apolo

Steve Roach - Structures of Silence

Marcy Z - Inward Harmony

CHAPTER IV

RESULTS

Results of the experiment were examined in the following manner:

1. Pre and post readings of the three experimental conditions were compared to data base norms accessible in the Bio-logic Brain Atlas computer program.

2. Microvoltage means for the delta and alpha frequency bands were figures for each pre/post reading of the three stimulus conditions (see Table 1). Change scores were computed by subtracting the pre microvoltage mean from the post microvoltage mean, adding those differences, and dividing by two (see Table 2).

3. Matched T-tests were performed on the mean change scores of the microvoltage values of the delta and alpha frequency bands (see Table 3).

The first six null hypotheses were tested using data base norm T-scores accessible in the Bio-logic Brain Atlas computer program:

Ho 1: There will be no significant cycle to cycle differences in brainwave activity, between the Bio-logic data base norms and the silence experimental listening condition, before music relaxation training.

Table 1

Pre/Post Microvoltage Means for the Three Experimental Conditions

	Delta Microvoltage Means			Alpha Microvoltage Means		
	Silence	Sedative	Stimulative	Silence	Sedative	Stimulative
			Subject 1			
Pre	70.86	70.73	72.32	85.65	92.15	91.75
Post	69.10	67.15	66.57	98.00	97.80	98.14
			Subject 2			
Pre	65.93	63.95	65.94	121.59	112.07	101.90
Post	65.20	69.14	71.80	77.20	126.77	123.78

Table 2

Changed Scores of Microvoltage Means

Conditions	Delta	Alpha
Silence	-1.25	-16.02
Sedative	.81	10.18
Stimulative	.06	14.14

Table 3

Matched T-tests of Change Scores

Conditions	df	*t*	*p*
Delta			
Silence vs. Sedative	1	-0.53	.69**
Silence vs. Stimulative	1	-0.24	.85**
Sedative vs. Stimulative	1	.53	.69**
Alpha			
Silence vs. Sedative	1	-0.80	.57*
Silence vs. Stimulative	1	-0.8	.56*
Sedative vs. Stimulative	1	-1.23	.43*

*one-tailed test.

**two-tailed test.

Ho 2: There will be no significant cycle to cycle differences in brainwave activity, between Bio-logic data base norms and the sedative music experimental listening condition, before music relaxation training.

Ho 3: There will be no significant cycle to cycle differences in brainwave activity, between Bio-logic data base norms and the stimulative music experimental listening condition, before music relaxation training.

Ho 4: There will be no significant cycle to cycle differences in brainwave activity between Bio-logic data base norms and the silence experimental listening condition, after music relaxation training.

Ho 5: There will be no significant cycle to cycle differences in brainwave activity between Bio-logic data base norms and the sedative music experimental listening condition, after music relaxation training.

Ho 6: There will be no significant cycle to cycle differences in brainwave activity between Bio-logic data base norms and the stimulative music experimental listening condition, after music relaxation training.

Observations of T-scores showed no significant differences between any of the three experimental conditions and the data base norms. Since no significant deviations were found, Null Hypotheses 1-6 were accepted.

To measure differences between silence, sedative music and stimulative music, microvoltage means were collapsed and transformed into changed scores. Matched t-tests were performed on the three experimental conditions using BMDP Statistical Software, Version PC90 (1990 IBM PC/MS-DOS), to test the following Null Hypotheses:

Ho 7: There will be no significant difference in delta brainwave production between the silence and sedative experimental conditions.

Ho 8: There will be no significant difference in delta brainwave production between the silence and stimulative experimental conditions.

Ho 9: There will be no significant difference in delta brainwave production between the sedative and stimulative experimental conditions.

Ho 10: There will be no significant increase in alpha brainwave production between the silence and sedative experimental conditions.

Ho 11: There will be no significant increase in alpha brainwave production between the silence and stimulative experimental conditions.

Ho 12: There will be no significant increase in ampha brainwave production between the sedative and stimulative experimental conditions.

Because the t-scores remained well within the area of no significance, and the resulting high range of probability, Null Hypotheses 7-12 were accepted.

Between the pre and post readings, Subject 1 showed a consistent decrease in the delta activity under each condition and an increased level of alpha production (see Figure 1).

Subject 2 showed less consistency between the pre and post test readings and produced a wider range of amplitude levels. Alpha production actually decreased during the silence condition of the post reading (see Figure 2). However, she reported having difficulty in quieting her mind. Despite such difficulty, she did increase alpha during both the sedative and stimulative music conditions.

Figure 1: Subject 1

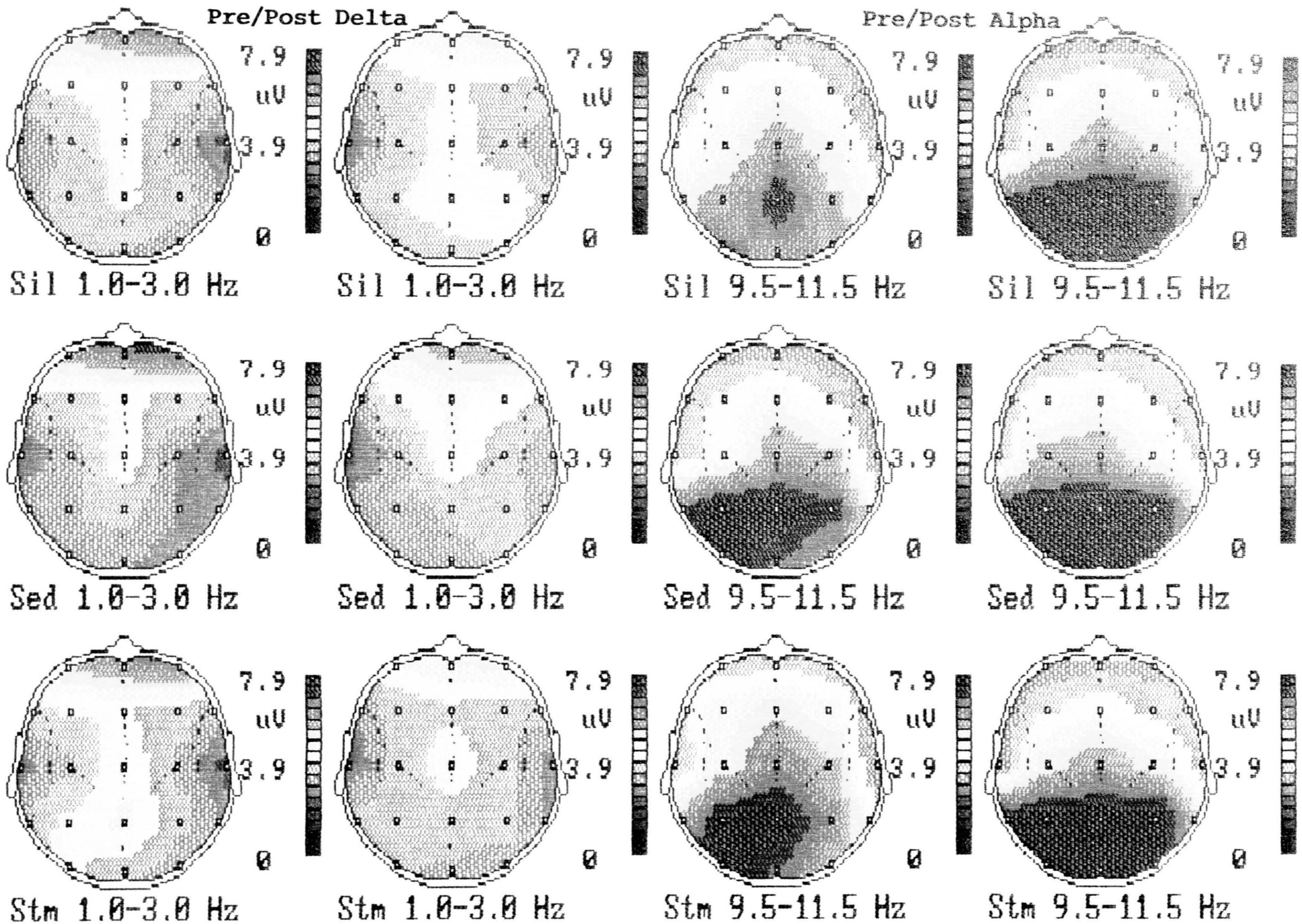
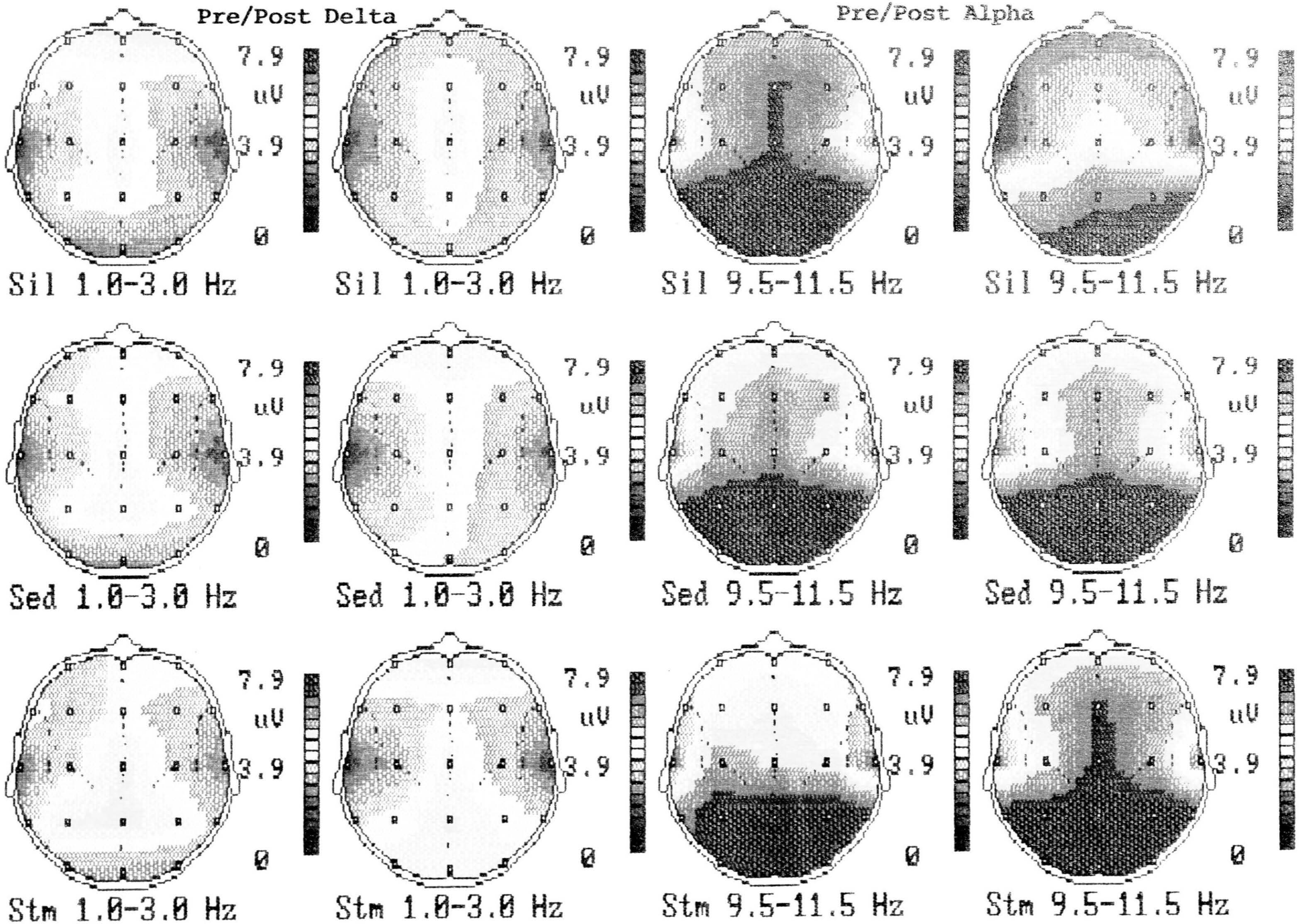


Figure 2: Subject 2



CHAPTER V

DISCUSSION AND RECOMMENDATIONS

The purpose of this study was to determine whether or not music relaxation training can affect brainwave activity under silence and contrasting music conditions. A Bio-logic Brain Atlas III was used to collect EEG readings on the three experimental conditions of (a) silence, (b) sedative music, and (c) stimulative music. The subjects were two female "nonmusicians," ages 22 and 23 years. Six 30 minute sessions of music relaxation training were conducted over a 2-3 week period, with EEG readings taken before and after the training. Brainwave activity was measured and examined relative to peak microvoltage and activity within frequency bands.

The pre and post readings were compared to data base norms accessible in the Biologic Brain Atlas computer program. No significant cycle to cycle deviations were found. To measure differences between silence, sedative music, and stimulative music, microvoltage means were collapsed and transformed into changed scores. Matched t-tests were performed on the three experimental conditions using BMDP Statistical

Software, version PC90 (1990 IBM PC/MS-DOS). No significant differences were found between the change scores of the microvoltage means.

This study should be a spring board for future research ideas. It demonstrated that changes of brainwave activity could be observed between contrasting musical stimuli, even when results were not statistically significant. It also indicated that it is possible to increase alpha production, and that alpha production may be related to the ability to relax. However, the high degree of technical skill necessary to learn to execute the proper electrode placement and EEG data collection limited the scope of this study. Because the measurement and placement of the 21 scalp electrodes took an amateur technician 1 to 1 1/2 hours, and because the available time on this EEG equipment was limited, it was necessary to limit the number of subjects and readings. Sitting very still and rigid for 1-2 hours during the preparation for and collection of the EEG data also must have affected the dispositions of the subjects, even though they were well aware of the tedious nature of the procedures. Another consideration would be the length of the exposure to the stimulus. Three to four minutes may not have been long enough to effect changes in processing of the stimulus by the subjects. For the experimenter who was nearly computer illiterate at the onset of this project, learning the use of the equipment and understanding the technology was a mind opening challenge well worth the time and effort, but that affected the pace and depth of the study. The work of this study, however, was executed very carefully and it is hoped that this project will contribute some insight into the utilization of topographic brainmapping in the area of brainwave/music research.

Recommendations

If a study of this nature were to be conducted again, the following procedures and guidelines would be recommended. Although the sedative and stimulative qualities of the musical selections were agreed upon by the subjects on this study, it would be important to establish more clearly what is considered to be "sedative" and "stimulative" music. This should be a preliminary study in itself that would involve a large number of the specific population type to be used for a brainwave/music relaxation study. For a more effective sample, the *N* should be increased and the length of exposure time to the stimulus expanded to a duration of at least six minutes. If a pre/post music relaxation training experiment were to be repeated, the use of a control group that does not receive training would be appropriate. Above all, it would be important to have the understanding and expertise available to facilitate a computerized statistical package capable of linking into the EEG technology and manipulating the vast amount of raw data.

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APPENDIX A

CONSENT FORM A

(Written Presentation to Subject)

Texas Woman's University
Human Subjects Review Committee

CONSENT FORM A (Written presentation to subject)

Consent to Act as a Subject for Research and Investigation:

The following information is to be read to or read by the subject. One copy of this form, signed and witnessed, must be given to each subject. A second copy must be retained by the investigator for filing with the Chairman of the Human Subjects Review Committee. A third copy may be made for the investigator's files.

1. I hereby authorize Kimberly Heft to perform the following procedures:

   A) Measure the subjects' heads following The International Ten-Twenty System of Electrode Placement, and mark it using a red non-toxic skin marking pencil. This procedure may take from 30 to 45 minutes.

   B) Once marked, each point will be prepped with an EEG skin abrasion paste, similar to a facial scrub, that will be applied with a cotton swab.

   C) At each point an electrode will be applied using an EEG paste designed for conduction and adherence.

   D) The subject will be required to sit very still during the time that the electrodes are in place. Movement could interfere with placement accuracy and electrode contact.

   E) When the electrode connection is completed, calibrations of impedance levels will be done. Steps B through E may take 30 to 45 minutes.

   F) The light in the room will be lowered, and baseline data will be collected following EEG protocol of eyes opened and eyes closed for 3 minutes.

   G) Then with eyes closed, EEG readings will be collected on 3 minutes of silence, 3-4 minutes of sedative music stimulus, and 3-4 minutes of abrasive music stimulus. Before each experimental condition, the subjects will be asked to mentally perform and verbally answer several simple math problems that will be dictated to them.

H) Pre and post reading procedures will be identical.

I) Between the pre and post readings, six 30 minute sessions of music relaxation training will be conducted over a 2-3 week period with tapes provided for home practice.

J) Seated in a comfortable recliner, subjects will be oriented to the procedures.

K) A progressive relaxation induction with musical background will be presented for 10 minutes, followed by a 5-8 minute period of free imagery.

L) A period of discussion for reflection on the experience will be used to process and wrap up each session.

2. The procedure listed in paragraph 1 has been explained to my by Kimberly Heft.

3a. I understand that the procedures or investigations described in paragraph 1 involve the following possible risks or discomforts:

A) Subjects may experience some tension and anxiety during the long and tedious electrode marking and placement procedure. The novelty of the experience may also create some anxiety for the subject.

B) Subjects may become disturbed by the disarrangement of their hair and the residue left in it from the EEG skin prepping and conduction pastes.

C) Some discomfort may be experienced during the abrading of the skin in preparation of electrode application.

D) Some discomfort may be experienced from the electrodes that are applied directly to the skin of the forehead. The EEG abrading and conduction paste sometimes causes a slight stinging sensation to skin not covered with hair.

E) Abrading of the skin and scalp may cause slight breakage of the epidermal layer.

F) Subjects may experience anxiety about the nonexistent risk of electrical shock by being connected to the Brain Atlas.

G) Subjects may experience irritation or discomfort from the abrasive music stimulus.

3b. I understand that the procedures and investigations described in paragraph 1 have the following potential benefits to myself and/or others:

A) Subjects may benefit from the procedures by increasing their ability to relax and remain focused under aversive conditions.

B) Participation in the study will contribute to the understanding of the effects music has on brainwave activity.

C) Participation in the study may expose the subject to new areas of interest and technology.

3c. I understand that no medical service or compensation is provided to subjects by the university as a result of injury from participation in research.

4. An offer to answer all of my questions regarding the study has been made. If alternative procedures are more advantageous to me, they have been explained. A description of the possible attendant discomforts and risks reasonably expected have been discussed with me. I understand that I may terminate my participation in the study at any time.

________________________ ________________________

Subject's Signature Date

If the subject is a minor, or otherwise unable to sign, complete the following:

Subject is a minor (age______), or is unable to sign because:____

Signatures:

______________________________ ______________________________
Witness Date

______________________________ ______________________________
Witness Date

APPENDIX B

GLOSSARY

GLOSSARY

Alpha Rhythm - Frequency range from 8 - 13 Hz. It is most easily observed in waking EEG of a normal adult who is relaxed with eyes closed and is most prominent in the posterior regions of the head. Alpha activity is attenuated by visual stimulation and increased mental activity. Voltage range is 20 - 60 uV.

Alternating Current (AC) - Electric current that is within a full cycle of 1/60 Hz. Flows in one direction and then reverses its direction. 60 Hz. AC is the current that flows through power lines in the United States and is commonly accessible.

Ampere (A) - Basic unit of current that expresses rate of flow.

Amplitude - Basic measurement of voltage. In EEG it is expressed in microvolts (uV).

Artifact - is electrical activity other than that generated by the patient's brain. It may be generated physiologically, or by external sources. Artifact can be difficult to detect even by the most experienced EEG technologist.

Beta Rhythm - Brainwave activity faster than 13 Hz. Its distribution is generalized. Voltage range is 5 to 20 uV.

Calibration - Determination of whether or not the amplitude of the deflections are equal in all channels. This procedure should be done before each recording.

Delta Activity - Frequency range is 0 - 4 Hz. Commonly has the highest amplitude of EEG frequency bands.

Derivations - The selection of the pair of electrodes connected to the input channels. The order of the derivations determine the picture of the brain displayed.

Direct Current (DC) - A form of electrical current in which the flow of electrons stay moving in one direction.

Fast Fourier Transfer (FFT) - is a computerized process that separates EEG signals coming from each electrode site. The process figures amplitude values for each electrode site at each .5 frequency level.

Ground - A wire or circuit that channels any current leakage or power surge to the earth where the conduction is halted.

Impedance - Measurement of total resistance between two electrodes or montages. Impedance is expressed as unit of resistance or ohm. If the impedance levels of electrodes are uneven, there will be imbalance of input to the amplifiers.

Inion - Lower edge of the protrusion of the occipital bone.

Lamba Wave - Distinguished by a sharp wave of 4 - 6 Hz. It occurs in the occipital area and is not observed when the subjects' eyes are closed or open in the dark. Lamba waves are normal.

Leakage Current - Normal but undesirable electrical current that originates usually form AC power sources and flow through conductive path or through the grounding wire. Leakage current from the EEG instrument to the ground should not exceed 100 uV. Leakage current from EEG amplifier input to the ground should not exceed 50 uV.

Montage - The arrangement of derivations in such a manner that forms an overall composite picture.

Morphology - Refers to the shape of the wave form.

Mu Rhythm - Frequency of about 9 Hz. but is not alpha rhythm. Observed primarily in the central area. Is characterized by distinct arch-like morphology and uniqueness of being blocked by movements such as a fist clenching or by engaging in such a movement. Voltage may range up to 80 uV.

Nasion - Bone indentation between the nose and the forehead.

Nonphysiological Artifact - Most commonly caused by electrostatic effect occurring between AC conductors and the electrode, patient, or the conducting body close to the patient. To minimize 60 Hz. artifact one can keep the electrodes clean, maintain even impedance levels, and keep impedance levels even.

Ohm - The basic unit of resistance. It is usually expressed as kilohms.

Ohmeter - Instrument used to measure resistance.

Physiological Artifact - The most common physiological artifact as follows:

1) muscle artifact, occurring most commonly in frontal and temporal areas.
2) electrocardiographic artifact, recognized by its rhythmicity and sharp wave forms.
3) eye movement, can simulate slow waves of frontal origin.

Other possible forms of physiological artifact include pulse artifact, glossokinetic potential, and respiratory artifact.

Potential - Refers to the degree of electrical activity.

Preauricular Points - Indentation directly in front of a triangular piece of cartilage (tragus), that covers the opening of the ear canal.

Referential Derivatives - A paired electrode recording technique that uses one of the paired electrodes as the reference to the other.

Reference Electrode - The electrode chosen of which the potential variations of the other electrodes are measured against.

Referential Montage - Consists of an electrode derivation in which each channel is referenced to a common electrode, most frequently being A1 and A2.

Sixty Hertz Rejection Filter - Reduces the 60 Hz. interference in EEG amplification system from nearby electrical equipment such as common room lighting.

Theta Activity - Frequency range of 4 - 7 Hz. It is rarely rhythmic. Voltage range is less than 15 uV.

Topographic Brain Mapping (TBM) - A computer technology that quantitatively analyzes raw neuroelectrical data and relates color to the amplitude distribution to provide a comprehensive data analysis.

Volt (V) - Basic unit of electromotive force.

APPENDIX C

FUNDAMENTALS OF ELECTROENCEPHALOGRAPHY

FUNDAMENTALS OF ELECTROENCEPHALOGRAPHY

The electroencephalogram (EEG) is the measurement of electrical activity generated by the nerve cells of the brain. The source of the electrical activity is the many nerve cells or neurons that exist in the outer surface of the brain. This electrical brainwave activity is very small and measures in units of microvoltage (uV) or a millionth of a volt. Electrical activity transmitted through the cortex to the scalp is picked up by the EEG electrodes, amplified, and recorded as rising and falling electrical potentials. The neurons generating these electrical potentials are changing sychronously, and rhythms of various types are being created.

Basic elements of neurological brainwave activity must be understood. As these electrical potentials are firing synchronously, the variability of the rhythms are occurring in the two dimensions of time and amplitude. Variability of time is expressed as frequency or cycles per second (Hertz). Amplitude is the intensity expressed in a measurement of voltage. Relative to EEG, this would mean

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SOURCE: Tyner, F. S., Knott, J. R., & Mayer, W. B. (1983). Fundamentals of EEG Technology. Volume 1: Basic concepts and methods. New York: Raven Press.

that for a 9.0 Hz. frequency, the recorded waveform would oscillate nine times during a one second period. On an EEG recording this would appear as waveforms with morphology displaying changes in the speed and strength of the electrical potentials.

Hans Berger discovered the first brainwave activity in 1924 and reported it in 1929. This first discovered rhythm pattern (labeled alpha) displayed a frequency range of approximately 8 to 12 Hz. and was observed dominantly in the back part of the head. Berger later observed a lower voltage, yet higher frequency rhythm (faster than 13 Hz.) that he labeled as beta waves. Two English electroencephalographers, W. Grey Walter and Vivian Dovey recognized and named theta waves (Frequency range of 4 to 7 Hz.), and identified the slower delta brainwaves of 4 Hz. or less.

There exists various types of EEG activity. Alpha activity ranges from approximately 8 to 13 Hertz. It is most easily observed in an adult who is awake, but relaxed with eyes closed. Alpha activity is most prominent in the occipital region and is attenuated by visual stimulation and increased mental activity. The voltage level for alpha activity ranges between 20 to 60 uV. Beta activity consists of frequencies of 13 Hertz or faster, and lower amplitude levels. Its distribution is more generalized and can commonly be seen in the frontal and central regions. The voltage level for beta activity ranges between 5 to 20 uV. Theta activity (4-7 Hertz) is rarely rhythmic. Small amounts of it can be seen in the central, temporal and parietal areas and its voltage level is less than 15 uV. Delta activity (0-3.5 Hertz) commonly has the highest amplitude of the EEG frequency bands. Mu Rhythm is a frequency of about 9 Hz. but is not alpha rhythm. Observed primarily in the central area, it is characterized by distinct arch-like morphology and has a unique characteristic of being blocked by fist clenching or similar movement. Voltage may range up to 80 uV. Lamba waves are distinguished by a sharp wave of 4 - 6 Hertz. It occurs in the occipital area and is not observed when eyes are closed or open in the dark. Lamba waves are normal.

Patient Safety

Because the process of EEG data collection involves connecting a patient to a powerful piece of electrical equipment, the issue of electrical safety needs to be addressed. Patient and operator safety can be reassured by adherence to equipment and operating guidelines.

EEG instruments are designed to transform alternating current (AC) taken from common 120V power mains to direct current (DC) which is a lower voltage range of 1 - 24V. This is necessary due to the low voltage sensitivity involved in EEG recording, and to hold the levels of leakage current to a minimum for the safety of the patient and operator. The EEG instrument also contains a circuit breaker to insure a shut down should a component fail.

To insure proper grounding the power cord of all EEG equipment must be of three-prong hospital grade. This means that the EEG instrument is grounded through the third (green) wire of the power cord. An ohmeter can be used to check the ground wire regularly by placing one probe of the meter in contact with the ground probe and the other in contact with the metal surface of the EEG instrument. The reading should be less than .1 ohm to be safe.

Assuring that the patient is safely grounded is accomplished by applying specific electrodes that connect the patient to ground wires of the EEG instrument. This also serves to protect the patient from acting as a receiving antenna for 60 Hz AC current. To further lessen the risk of the patient becoming a path for electrical current to the ground, optical coupling devices are used in the input circuits which would cut off the patient from contact with any high power voltage.

Another important aspect of the patient's safety is proper sterilization of electrodes. This involves thoroughly cleansing each electrode of conduction paste and skin scrub with a toothbrush and water, washing them with a mild soap, and soaking the electrodes in a disinfecting solution.

Artifact

A major area of concern in EEG technology is artifact, electrical activity other than that generated by the patient's brain. It may be generated physiologically, or by external sources and can be difficult to detect even by the most experienced EEG technologist. The most common types of physiological artifact are 1) muscle artifact, occurring most commonly in the frontal and temporal areas, 2) electrocardiographic artifact, which can be recognized by its rhythmicity and sharp waves, and 3) eye movement which can simulate slow waves of frontal origin. Other forms of physiological artifact are pulse artifact, glossokinetic potential (originating from the tongue), and respiratory artifact. The most common nonphysiological artifact comes from the 60 Hz. A.C. that run throughout most buildings for lighting and power. The actual artifact is caused by the electrostatic effect that occurs between the A.C. conductors and the EEG electrodes, or between the A.C. conductors and a conducting body close to the patient. Steps that can be taken to minimize 60 Hz. A.C. artifact are 1) keep the electrodes clean, 2) maintain low impedance levels to decrease 60 Hz. interference, and 3) maintain equally balanced impedance levels.

With the rapid evolution of computer technology, instruments capable of monitoring and analyzing brainwave activity have reached new dimensions. Topographic brainmapping (TBM) is a computer technology that analyzes raw EEG data and relates color to the amplitude distribution to provide a comprehensive data analysis. The raw EEG data from each electrode site or input channel is converted to digital form and processed through a computational technique called Fast Fourier Transform (FFT). This produces a microvoltage power of each input channel at each .5 Hertz frequency level. Thus specific power values of any frequency level or range can be scrutinized. TBM provides data information concerning frequency, amplitude, waveform morphology and has the ability of displaying the information using various formats.

In the medical field, EEG has been important in developing diagnostic procedures for disease. Its major contribution, however, has been in its ability to distinguish between brain function physiological disturbances caused by structural lesions and those disturbances not caused by structural lesions. As EEG technology becomes more accessible, brainwave research will be utilized in many disciplines.

APPENDIX D

THE TEN-TWENTY INTERNATIONAL SYSTEM OF ELECTRODE PLACEMENT

THE TEN-TWENTY INTERNATIONAL SYSTEM
OF ELECTRODE PLACEMENT

Collection of EEG data involves placing at least twenty-one electrodes in carefully determined locations on the scalp of the subject. The Ten-Twenty International System of Electrode Placement was developed in 1958 to standardize EEG practices and terminology. Its measurement procedure spaces electrodes equally using skull landmarks that are relative to underlying cortical structures.

The 10-20 System of Electrode Placement means that the electrodes are spaced either 10% or 20% of the total distance between a given pair of skull landmarks. The use of percentages in determining measurement allows for differences in head sizes and shapes. The key to accurate electrode placement then involves careful determination of skull landmarks and extremely precise measurement and marking. Studies have determined room for error to be within a single centimeter (Tyner, 1983).

The four crucial skull landmarks are the nasions, the inion, and the right and left preauricle points. The

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SOURCE: Harner, M. A., & Sannit, T. (1974). _A review of the international ten-twenty system of electrode placement_. Glass Instrument Company.

nasion is the bony indentation where the forehead and the nose meet. The inion is the protruding ridge of the occipital bone with a depressed ridge right below. Although more difficult to find, but can be felt by running the finger up the back of the neck and tilting the head backward and forward. The inion is marked at the bottom of the ridge and lies even to the preauricle points. The preauricular points can be found easily by running the fingers up and down the anterior cartilage (tragus) of the ear with the patient's jaw slightly opened. Finding the four landmarks is the first step to the measuring procedure.

With the development of the 10-20 International System of Electrode Placement, the nomenclature was also standardized. The alphabetic characters correspond to the area of the brain over which they are located: Frontal (F), Central (C), Parietal (P), and Occipital (O). The subscript "z" refers to the midline zero reference. The even numbered electrode sites are located in the right side of the head and the odd numbered electrode sites are located on the left. When accurately measured, the left and right electrode sites balance each other. Symetrical balance of electrode placement effects voltage synchronization during recording.

The sequence of measurement is crucial, particularly the first measurement of nasion to inion. If measured inaccurately, so will all succeeding measurements. The steps of measurement are as follows:

1. Locate the four skull landmarks.

2. Measure the distance from nasion to inion.
   a. Calculate 10% of the total distance between the nasion and inion, and use that figure to measure up from the nasion to mark the frontal polar or Fp point.
   b. Use the same 10% measurement to mark the O or occipital point above the inion.
   c. 20% of the nasion to inion measurement is used to mark back from Fp and locate Fz, Cz, Pz, and verifies O position.

3. Measure the distance between left and right preauricle points making sure to cross through Cz.
   a. Using 10% of the distance between the two preauricular points, measure up from each point and mark T3 and T4.
   b. Using 20% of the distance between the two preauricular points, measure up from the T3 and T4 to find C3 and C4. 20% up from each of those points should verify Cz.

4. Measure the circumference of the head, lining the tape even with Fz, T3, T4, and O. Figure 10% of the circumference of the head, and use that measurement to make ten equal vertical marks using the following step:
   a. The first measurement straddles the midline Fp, marking Fp1 in the left, and Fp2 on the right.
   b. Measuring along the circumference line, 10% back from Fp2, F8 is marked. 10% back from F8 should verify the accuracy of T4.
   c. Measuring 10% back from T4, a vertical mark is made for T6.
   d. Measuring 10% back from T6, a vertical mark is made for O2.
   e. For the left side of the head, 10% back from Fp1 locates F7.
   f. 10% back from F7 should verify T3.
   g. 10% back from T3 locates T5.

   h. 10% back from T5 should verify O1.
   i. Verify that the distance between O1 and O2 is 10% of the total circumference.

5. Complete the marking of the lateral chain of electrodes along the temporal line by meeting the vertical 10% mark with horizontal marks at the Fp1, F7, T5, O1, Fp2, F8, T6, and O2 points.

6. Measure the distance from Fp1 to O1.
   a. Complete the marking of C3 with a vertical mark at the halfway point.
   b. F3 is located halfway between Fp1 and C3.
   c. P3 is located halfway between C3 and O1.

7. Measure the distance from Fp2 and O2.
   a. Complete the marking of C4 is with a vertical mark at the halfway point.
   b. F4 is located halfway between Fp2 and C4.
   c. P4 is located halfway between C4 and O2.

8. Measure the distance between F7 and F8 passing through Fz.
   a. Half of that distance determines the final mark for Fz.
   b. The final mark for F3 is located halfway between Fz and F7.
   c. The final mark for F4 is located halfway between Fz and F8.

9. Measure the distance from T5 to T6 passing through Pz.
   a. Half of that distance determines the final mark for Pz.
   b. The final mark for P3 is located halfway between Pz and T5.
   c. The final mark for P4 is located halfway between Pz and T6.

This completes marking for the 19 electrode positions on the scalp. There is a horizontal and vertical coordinate for each position. Two other grounding electrodes A1 and A2 are placed on the left and right ear lobe, respectively, to complete a full 21 electrode placement.

After the scalp is carefully measured, each coordinate position is scrubbed lightly with EEG skin prepping paste. When all 21 electrode positions have been prepared, the electrodes can be applied suing EEG paste for adhesion and conduction. The electrode jacks are plugged into the corresponding positions in the head box that is marked with numerical anatomical descriptors to identify all of the electrode positions and is connected to the amplifier of the EEG instrument by a long input cable.

APPENDIX E

SUBJECT INFORMATION FORM

SUBJECT INFORMATION FORM

1. Musical Background

    a. Training in the past three years
    b. Elementary
    c. Jr. High
    d. High School
    e. Private
    f. Church
    g. Dance
    h. Other

2. Musical Preferences

3. Age

4. Sex

5. Dominant Hand

6. General Health

7. occupation

    a. PT or FT?
    b. Hours
    c. School class load

8. What motivated you to check into participating in this study?

9. What do you want to get out of this experience?

APPENDIX F

COLLECTION FORM

COLLECTION FORM

Subject________________________________ Pre_____ Post_____

Date____________________________________

______Eyes Open

______Eyes Closed

______2 + 6   8 - 3   7 + 2

______Silence (3 minutes)

______3 + 5   6 - 4   3 + 7

______Stimulative Music

______ 4 + 3   9 - 1   1 + 7

______Sedative Music

COLLECTION FORM

Subject______________________________ Pre_____ Post_____

Date_________________________________

______Eyes Open

______Eyes Closed

______2 + 2   9 - 3   8 + 2

______Silence (3 minutes)

______1 + 5   8 - 4   3 + 2

______Sedative Music

______ 6 + 3   4 - 1   2 + 7

______Stimulative Music