THE DIFFERENTIAL EFFECTS OF LEFT EAR VERSUS RIGHT EAR VERSUS BOTH EARS INPUT UNDERBIOFEEDBACK OR RELAXATION TAPE CONDITIONS IN LOWERING FRONTALES ELECTROMYOGRAPHIC LEVELS

DISSERTATION

Presented to the Graduate Council of the

North Texas State University in Partial

Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Charles E. Ginn, Jr., M.A.

Denton, Texas

May, 1984

Ginn, Charles E., Jr. Differential Effects of Left Ear Versus Right Ear Versus Both Ears Input Under Biofeedback or Relaxation Tape Conditions in Lowering Frontales Electromyographic Levels. Doctor of Philosophy (Health Psychology/Behavioral Medicine), May, 1984, 70 pp., 11 tables, 3 figures, references, 82 titles.

This investigation focused on two major areas of investigation, (a) the differentiation of functions between the two cerebral hemispheres and (b) the effectiveness of electromyographic biofeedback versus relaxation tape input as methods of lowering levels of arousal. The purpose of the study was to evaluate the differential effects of EMG biofeedback and relaxation tape input to the right ear only, to the left ear only and to both ears in a strongly lateralized population.

Subjects were 56 students recruited from undergraduate psychology classes. To be included in the study, subjects had to score at minimum, and Edinburgh Handedness Inventory Laterality Quotient of 68, Declie = Right 3, and had to demonstrate a right ear advantage on the Dichotic Listening Task for Words.

Analysis of variance of microvolt changes from baseline showed the Left Ear Biofeedback group to be superior to all other conditions after 5 minutes, superior to the Right Ear

Biofeedback and Control groups after 10 minutes, and superior to the Right Ear Biofeedback, Right Ear Relaxation Tape, and Control groups after 15 and 20 minutes.

Analysis of covariance with the baseline measure at the covariant showed biofeedback training to be superior to relaxation tape input. This analysis also showed left ear input to be superior to both ears and right ear input, and both ears input superior to right ear input.

The results imply that laterality of input has a significant effect on a behaviorally complicated task for strongly lateralized normal individuals. However, caution should be exercised to avoid over emphasizing the differences noted between the various treatment and ear conditions.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

THE DIFFERENTIAL EFFECTS OF LEFT EAR VERSUS RIGHT EAR VERSUS BOTH EARS INPUT UNDER BIOFEEDBACK OR RELAXATION TAPE CONDITIONS IN LOWERING FRONTALES ELECTROMYOGRAPHIC LEVELS

This study was concerned with two major areas of investigation. The first involved issues related to the differentiation of functions between the two cerebral hemispheres. Recently, there has been an increase in research pertaining to human cerebral asymmetry. Accompanying this has been a rise in the number of psychological and physiological processes that have been related to hemispheric lateralization (Bradshaw & Nettleton, 1981). Although Paul Broca postulated in 1861 that the left hempishere was heavily involved in language, the notion that the two human cerebral hemispheres have different functions was given impetus by the work of Sperry and his colleagues with patients whose hemispheres were separated surgically (e.g., Gazzaniga, Bogen, & Sperry, 1963).

Among the mass of data that have been generated on the functional differences between the two halves of the brain are findings suggesting that emotional processes may be lateralized. Recently, studies attempting to localize various behavioral processes to one or the other side of the brain have appeared in the literature at the rate of three or four a week (Allen, 1983). In addition to reviews on emotional behavior and asymmetry of function were summaries of research related to general functional asymmetries, to anatomical differences between the two cerebral hemispheres, and to a common method of studying functional and anatomical asymmetries, the dichotic listening task (Kimura, 1961).

The second area investigated in the this study was over the effectiveness of electromyographic (EMG) biofeedback training versus other forms of relaxation training as methods of lowering levels of arousal. Various forms of biofeedback and relaxation techniques have been used in the treatment of medical and stress related disorders. The biofeedback treatments for stress and anxiety which often accompanies emotional arousal have generally have been on training to facilitate muscle relaxation. The most common form of this has involved EMG biofeedback assisted training of the forehead muscles (Budzynski & Stoyva, 1977; Lee, Baldwin, & Lee, 1977). Although many studies have found frontales biofeedback to be significantly more effective in reducing levels of muscle tension than commonly used relaxation procedures, there have been questions about the viability and efficacy of this type of EMB biofeedback (Alexander & Smith, 1979). In addition to a review of this controversy, a summary of the findings on how cerebral laterality may influence biofeedback tasks was also included.

Cerebral Laterality

Anatomical Differences. Because of the apparent differences in functions of the two hemispheres, investigators have looked at the structure of the brain in attempts to account for these findings. Most studies of left-right asymmetries have been based on the assumption that a large majority of normal individuals have speech and language in the left hemisphere. Anatomical support for this has been post-mortem findings that the planum temporale, located on the upper surface of the temporal lobe, was significantly larger on the left than the right in 65 of 100 brains (Geschwind & Levitsky, 1968). Also using post-mortem data, Rubens (1977) found that the Sylvian fissure, which is located in the same general area as the planum temporale, was longer in the left hemisphere than in the right.

Witelson (1983) has gathered post-mortem anatomical measures on a small number of individuals (N = 12) for which she had earlier gathered functional lateralization data including hand preference, finger tapping rate, and ear asymmetry on verbal and melodic dichotic tasks. She reported that the anatomical and functional findings are highly correlated and supportive of the idea that anatomical asymmetry may be a substrate of differential hemispheric functioning. One of her subjects, who was right handed by a hand preference questionnaire, showed little ear asymmetry on the linguistic dichotic tasks and had a larger right planum. Also, this subject's tapping speed with the right index finger while doing concurrent verbalization showed virtually no interference effect which suggests that his language was not located soley in the left hemisphere (Hicks, Bradshaw, Kinsborne, & Feigin, 1978).

Using Xenon regional Cerebral Blood Flow (rCBF) which is an imaging technique that has allowed for in vivo anatomical studies, Gur, Packer, Hungerbuhler, Reivich, Obrist, Amarnek, and Sackeim (1980) found that there is more gray matter relative to white matter in the left hemisphere than in the right. This difference was particularly noticeable in the frontal and pre-central areas. Other reports not directed at attempting to specify right-left differences have also reported higher blood flow in the frontal regions than in other parts of the brain in normal resting subjects receiving no stimulation (Mamo, Philippe, Meric, Luft, & Seylaz, 1983). The pattern changes to greater posterior flow when subjects are reading, listening, or doing mental visual-spatial types of tasks (Ingvar, 1976).

Other left-right differences that have been reported are that the right hemisphere tends to weigh more than the left and that the anterior parts of the brain's of right handed individuals are wider on the right and the posterior areas are wider on the left. In left handers, the anterior areas still tended to be wider on the right, but were more often the same size than in right handers. Unlike the right handers, the posterior areas of left handers tended to be wider on the right (LeMay, 1976).

Structural brain asymmetries have also been reported in psychiatric patients. There has been a large amount of evidence reported indicating left hemisphere abnormalities in a subtype of schizophrenia. These have included abnormal computer assisted tomograms, abnormal rCBF (Franzen & Ingvar, 1975; Ariel, Golden, Berg, Quaife, Dirkson, Wilson, & Graber, 1983) and abnormal cerebral utilization of glucose (Buchsbaum & Ingvar, 1982). Several explanations have been suggested to account for these findings, including dysfunctions of the left temporal lobe, abnormal temporal-frontal connections and abnormal temporal-frontal-limbic connections (Nasrallah, 1982). These interpretations have been controversial (Seidman, 1983).

Functional Asymmetries. The different functions related to cerebral asymmetry have been subjects of symposia, textbooks, and review articles (e.g., Allen, 1983; Segalowitz, 1983; Bryden, 1982; Kinsborne, 1982; Bradshaw & Nettleton, 1981; Denenberg, 1981; McGlone, 1980; Wexler, 1980; New York Academy of Sciences, 1977; Searlemen, 1977; Corballis & Beale, 1976). In addition to postulating differences between right brain and left brain functions in normal intact individuals, topics addressed have included laterality differences between normals and psychiatric populations, differences among psychiatric groups, and differences between males and females. Some of the more salient differences and models of functional laterality were reviewed.

The most common dichotomy ascribed to hemispheric specialization of function has been that of a verbal left versus a non-verbal right hemisphere. Aspects of this have included verbal-musical and verbal-visual dichotomies. Although the left hemisphere has been established as important for language, the right hemisphere may also have a role in the reception and production of verbal communication. What has been lateralized may be the ability to produce speech rather than speech comprehension (Searleman, 1977). However, damage to the right hemisphere has interfered with the production and the reception of prosody in speech (Ross, 1981). With music, Shanon (1980) has found a left hemisphere advantage in trained musicians for the perception of complex melodies. Visual/spatial functions are not wholly localized in the right hemispheres as left posterior damage has produced visual constructive deficits (DeRenzi, 1982). Also, intact individuals have shown a left hemisphere advantage on visual/spatial tasks (Yandell & Elias, 1983).

Another commonly reported dichotomy has been that of a holistic right hemisphere and an analytic left one (Nebes, 1978). The right hemisphere has been viewed as superior at perceiving the relationships between the parts and the whole of a stimulus. Arguments against have claimed that right hemisphere advantages depend on the involvement of manual activities in the perception of spatial relationships and not on a general visual/spatial superiority per se (Le Doux, Wilson, & Gazzaniga, 1977). Somewhat related to the holistic/analytic split has been the diffuse/focal distinction, as relatively little damage to the left hemisphere has usually resulted in a specific loss of function while damage to the right has had to be much greater to disrupt specific behaviors (Semmes, 1968). Similar also to the holistic/analytic differentiation has been that of parallel processing versus serial processing (Cohen, 1973). That the left hemisphere has appeared more dependent on the number of features that make up stimulus than the right has been the basis for the latter dichotomy. However, the difference in reaction times between the hemispheres, which has been used to support this view has not held up across different types of input (White & White, 1975).

Instead of viewing hemisphereic specializtion of functions as being composed of rigid dichotomies, Bradshaw and Nettleton (1981) have proposed a continuum of functions between the hemispheres. The differences are seen as being quantitative rather than qualitative, that is, of being of degree and not of kind. The left hemisphere is seen as best at discriminations involving duration, temporal order, sequencing, and rhythm. This holds for sensory and motor levels of processing. The right hemisphere is characterized as involved in mapping of the exteroceptive body space and the position of the distal portions of the body. This is proposed for actual and target positions for the individuals body and as well as for objects in the environment.

In a review of the laterality literature, Allen (1983) has cataloged the various models of hemispheric specialization into five general classes. These are a) unilateral, which is similar to the dichotomy of function model; b) cooperative interaction, which claims that the two hemispheres are doing the same thing and the overall performance is the resultant vector; c) negative interaction, which holds that both hemispheres are in operation at the same time but one is being inhibited either unidirectionally or reciprocally; d) parallel, which holds that both hemispheres are operating at the same time simultaneously and independently of each other (this is a bilateral non-interactive model); d) allocation, which holds that both hemispheres have the capacity to perform a task but only one does so at a time. This last model is divided into three sub-classifications; a) input, where the nature of the stimulus is critical for how the processing will take place; b) output, where the final but not the initial stage of processing is allocated to one or the other hemispheres; c) switching, which is a model which allows for the switching of processing control back and forth between the two hemispheres.

Based on his review, Allen (1983) has proposed a subprocessor model which appears to be somewhat a combination of the unilateral specialization, cooperative interaction and allocation models. He offers that within each hemisphere there is a finite and somewhat limited number of subprocessors which are used in the performance of psychological functions. The individual subprocessors accept particular neural information, perform some specialized operation on it, and then pass the transformed information along to other subprocessors for eventual output. He assumes that the subprocessors differ in the types of processing they do (function) and among the hemispheres (location). Allen's model is merely heuristic as he offers no information about the nature of the subprocessors on how or why data would be analyzed by one subprocessor but not by another. He appears to be hypothesizing that all input goes through all subprocessors which imply a rigid mode of information processing.

In a model somewhat similar to Allen's, Kinsborn (1982) has offered a functional distance principal as an explanation for hemispheric lateralization. He states, "Lateralization provides neural distance, not between alternative mutually exclusive acts, but between complimentary component processes that combine to program a unitary pattern of behavior" (p. 413). As the result of the network and functional distance principals, separate control centers that are functionally close together will conflict if they are independently engaged in unrelated activity in that highly connected areas lend themselves to the successive use of information in processing sequences. Lateral hemisphereic specialization is seen as rising from the need to perform different classes of cognitive operations with minimal cross talk and not as a way of containing conflicting minds within separate packages. Kinsborn does not hold that the two hemispheres are not differentiated functionally. What he considers to be lateralized is the mental operations that pertain to focal attending. The left hemisphere is best at the extraction of information serially and feature by feature. The right hemisphere is at the same time registering the relations among the features that the left hemisphere has extracted. This allows the individual to attend to and to make finer and finer discriminations before committing to actions.

Based on general systems theory, Denenberg (1981) has developed a model for the study of brain organization involving three hypothetical processes: a) interhemispheric coupling coefficient; b) hemisphereic activation; and c) interhemispheric inhibition. Interhemisphereic coupling attempts to define a system (the functions of the brain) in terms of the relationships between the component parts (the two hemispheres) and the overall output of the system (overt and covert behavior). In order for the brain to be considered a system, the variance of the whole must be significantly less than the sum of the variance of the separate components. The variance of the output of the intact brain is seen as the sum of the variance of the left hemisphere plus the right hemisphere, minus the covariance of the two hemispheres. For example, if each hemisphere bias a person to look or move in a particular direction, the resultant direction will be a function of the difference in the strength of response of each hemisphere. Because the two hemispheres receive similar information to process and have similar propensities to respond, they are seen as being positively correlated. This correlation is the hemispheric coupling coefficient and is based on the variance of the hemispheres working together.

To Denenberg (1981), activation and inhibition are seen as functions of hemispheric specialization. For example, words and sentences can activate the left hemisphere more than the right, while certain spatial tasks can activate the right more than the left. Activation in one hemisphere can be independent of what is happening in the other and inhibition means that one hemisphere can block what is happening in the other either partly or wholly. Inhibition is assumed to combine algebraically with activation and the hemisphere with the larger resultant magnitude will control performance.

Asymmetry of Emotion. As with other functional asymmetries, there have been several general opinions regarding the lateralization of emotional processes. Bryden and his coworkers (Bryden, Ley, & Sugerman, 1982; Ley & Bryden, 1982) have claimed that emotional stimuli, whether positive or negative, are more accurately perceived by the right hemisphere. They also claim that the display of emotion is more striking on the left side of the face than on the right. Like Bryden, Moscovitch, & Olds (1982) found that in right handers, more expressive emotional movements are made with the left side of the face. However, this difference was not seen in left handed individuals.

A second view of the hemispheric differences in emotions has been that instead of a strong right hemisphere superiority for all emotions, the left hemisphere is more involved than the right for positive emotions and the right is more involved for negative ones. Using lateral eye movements in a non-clinical population as an indicator of hemispheric activity, Ahern & Schwartz (1979) have reported that questions related to positive emotion evoked movements suggestive of relative left hemisphere involvement. Also negative emotion questions evoked movements suggestive of greater right hemisphere involvement. Sackeim, Greenberg, Weiman, Gur, Hungerbuhler, and Geschwind (1982) have reported evidence that support this view although their data was based on brain damaged and seizure patients. Sackeim et al. proposed that the differences noted in the differential processing of negative and positive emotions may reflect asymmetries in the distribution of certain neurotransmitters in the two sides of the brain. Also supportive of the findings that the right hemisphere may be more involved in negative emotions than positive ones have been reports of greater right hemisphere activation during stress (Tucker, Roth, Arneson, & Buckingham, 1977).

A third interpretation of emotional asymmetry addressed differences seen between spontaneous and deliberate expressions of emotion. Ekman, Hager, and Friesen (1981) have reported more consistent asymmetry is seen in deliberate facial expressions than in the spontaneous ones. With deliberate expressions, the asymmetry that was found favored the left side of the face. Spontaneous smiling was often asymmetrical but the frequency of asymmetry was evenly divided between those favoring the left side and those favoring the right side. In attempting to explain their findings, Ekman et al. cited neurological findings that lesions in the pyramidal motor system have impaired the ability to perform a facial movement on request yet have spared the ability to do the movements spontaneously. The reverse of this has been seen with lesions of the non-pyramidal systems. That is, with a pyramidal injury, a person may not be able to smile on request but can smile if amused by something. The opposite is seen with non-pyramidal damage. Because of the increase in stronger left facial asymmetries in deliberate actions, a greater involvement of the right hemisphere than the left in deliberate facial movements was suggested. Also postulated was that the right motor cortex is more involved than the left in any cortically directed nonverbal facial movement.

Dichotic Listening. Because peripheral sensory receptors project primarily to the contralateral side of the brain, it has been possible to present stimuli for initial processing selectively to one hemisphere or the other. Doing this has allowed for the assessment of the functions and interactions of sensory input to different brain regions (Springer & Deutsch, 1982).

An important method of studying the functional differences between the two cerebral hemispheres has been the dichotic listening task. In this, two different auditory signals are presented at the same time, one arriving at each ear. The individual then reports what has been heard. In general, there has been a right ear advantage reported for speech-related material, which supposedly reflects the left hemisphere superiority for such input (Kimura, 1961, 1967; Broadbent & Gregory, 1964; Satz, 1968). Generally, this specialization of hemispheric processing of auditory input has held across age groups (Schulman-Galambos, 1977), with normal and learning disabled children (Obrzut, Hynd, Obrzut, & Pirozzolo, 1981), and has not been found to be related to sex, to reading ability, or to socioeconomic class (Davidoff, Done, & Scully, 1981). Surgically severing the corpus callosum has magnified the dichotic effects (Walsh, 1978).

The auditory pathways are complex as input is transmitted both to the ipsilateral and contralateral hemispheres. However, the contralateral auditory cortex receives more fibers than the ipsilateral one (Rosenzweig, 1951). With dichotic presentations, the ipsilateral cortical evoked response has shown a longer latency than the contralateral response. This increase in latency may be due to simple delay in the ipsilateral channel or to suppression of that channel (Monomel & Seitz, 1977).

Although a right ear advantage usually is reported with the dichotic presentation of speech material which supposedly reflects the location of language comprehension in the left hemisphere for most individuals, there are procedures and conditions that have modified the dichotic effects (Berlin, 1977). The reports of right-ear superiority on dichotic listening measures in normal right handers have been in the range of 75 to 85% (Bryden, 1982). This suggests that 15 to 25% of right handed individuals may have language located in the right hemisphere. However, these figures are well above the 1.8% of right handers reported aphasic after right hemisphere damage (Millar & Whitaker, 1983) and the 4% of right handers that have been estimated to be non-left hemispheric dominant for language (Geschwind & Levitsky, 1968). Although correlations between perceptual and anatomical asymmetries have been high, they are less than perfect. Nevertheless, perceptual asymmetries may be a more precise index of functional lateralization than simple hand preference (Witelson, 1983).

Biofeedback

Biofeedback and Relaxation. Biofeedback has been based on the principle that to learn to perform a particular behavior, it is best to receive feedback about the consequences of the behavior so compensatory adjustments can be made. Biofeedback has been used in attempts to influence various physiological processes previously thought to be beyond the range of conscious mediation (Gatchel & Price, 1979).

Types of biofeedback that have been used in clinical populations have included: electroencephalographic feedback in the treatment of epileptics (Lubar & Bahler, 1976); photoplethysmographic blood volume changes and temperature changes in Reynaud's disease (Blanchard & Haynes, 1975; Shapiro & Schwartz, 1972), blood pressure feedback in hypertension (Benson, Shapiro, Turskey & Schwartz, 1971); beat-by-beat heart rate feedback for premature ventricular contractions (Weiss & Engel, 1971); integrated EMG activity in disabled neurological patients (Brundy, 1982); frontalis EMG feedback in tension headaches (Haynes, Griffin, Mooney, & Parise 1975); feedback of peripheral vasodilation in migraine headaches (Sargent, Green, & Walters, 1973); and EMG feedback for chronic stress or anxiety (Townsend, House, & Addario, 1975). It has been the latter uses (in treating stress and anxiety) that has attracted many to biofeedback (Gatchel, 1979).

Although biofeedback has been used to treat a variety of ailments it has been suggested that it is no more effective than simpler techniques such as some form of relaxation training (Miller, 1982). For example, relaxation training involving listening to soothing sounds has been demonstrated to be effective in the reduction of anxiety (Stoudenmire, 1975) and in lowering frontales EMG levels (Miller & Bornstein, 1977). In the latter study, nine different relaxation procedures other than biofeedback were compared. Among these were progressive muscle relaxation, relaxation training with imagery, and self-relaxation with music. All conditions resulted in lowering of frontales EMG levels and there were no differences among the different procedures.

In a review of the literature comparing biofeedback with various forms of relaxation training in the treatment of psychophysical disorders, Silver and Blanchard (1978) concluded that for many conditions, there is no consistent advantage for one treatment over the other. Excluding the uses of EMG feedback in the treatment of neuromuscular disorders, Alexander and Smith (1979) have claimed "It can now be rather confidently stated that feedback of EMG activity recorded from electrodes located on the forehead seems to have no unique properties nor probably even any nonunique properties of interest" (p. 123). A specific argument against the use of frontales EMG biofeedback has claimed that it has no generalized effect as no single muscle group can be an indicator of the arousal level of the individual (Gatchel, Korman, Weis, Smith, & Clark, 1978).

In disagreeing that EMG biofeedback is not a more effective means of relaxation training than other methods, Qualls and Sheehan (1981) state:

> A review of the frontalis electromyograph biofeedback literature clearly demonstrates that electromyograph biofeedback compares favorably with other relaxation procedures, though some reviewers have prematurely concluded that alternative relaxation treatments are preferable on a cost-benefit basis (p. 21).

The authors feel that information on variables that have influenced performance during biofeedback have not been adequately specified and until this is done, definitive conclusions as to the efficacy of this treatment cannot be made.

Biofeedback and Cerebral Laterality. That hemispheric specialization might also apply during biofeedback tasks has been investigated. Greenstadt, Schuman, and Shapiro (1978) had subjects attempt to increase heart rate with biofeedback information which was a click presented every time the interbeat interval was shorter than a present criterion. Subjects were given the feedback through the left ear or through the right ear only. A both ears condition was not reported. Contrary to the authors' expectations that heart rate during biofeedback training would be associated with right hemisphere involvement, there was a right ear (left hemisphere) superiority during the feedback task in increasing the heart rate. The magnitude of the change in heart rate was greater than the authors had seen with any other varieties of feedback. All subjects in the study were right handed by self-report.

Suter (1980) found neither hand nor ear effects during biofeedback for finger temperature changes. In the one session study, each subject attempted to raise finger temperature while receiving right ear-right finger, right ear-left finger, left ear-left finger, and left ear-right finger tonal feedback. Each subject also attempted to lower finger temerature under the same ear-finger conditions listed above. As with Greenstadt et al. (1979), there was no both ears feedback condition reported and all subjects were right handed by self-report.

Sussman and his colleagues (Sussman, 1971, 1970; Sussman & MacNeilage, 1975; Sussman & Westbury, 1978) have reported a series of studies on hemispheric lateralization of function which have used a dichotic monitoring tasks that appears to be somewhat a combination of a form of a dichotic listening task and biofeedback. In these works, the common procedure has been to present a varying target tone to one ear and a cursor tone to the other. The criteria involved matching the target tone with the cursor tone by controlling the cursor with either lateral tongue movements or with hand movements. Subjects have been more accurate in tracking when the cursor tone was presented to the left ear while the target tone was going to the right ear. The conclusion Sussman has reached is that the matching of ongoing motor activity to a standard (which involves evaluating feedback in terms of goals) in primarily a function of the left hemisphere.

The purpose of the present study was to evaluate the differential effects of EMG biofeedback to the right ear, left ear, and both ears while subjects attempted to lower frontalis levels. Also investigated were the effects of right ear, left ear, and both ears input of a relaxation tape while the subject used the tape input to assist them to relax. A no feedback, no relaxation tape condition was also studied.

Method

Subjects

The subjects were 56 students from undergraduate psychology classes at North Texas State University. Only those who were right handed were asked to participate in the screening processes. To be included in the study, subjects had to score at minimum, a Laterality Quotient of 68, Decile = Right 3 as measured by the Edinburgh Handedness Inventory (Oldfield, 1971). Also, all subjects had to show a right ear advantage on the Dichotic Listening Task for Words (Kimura, 1964). Informed consent was obtained prior to the dichotic word screening (see Appendix A). A total of 92 individuals were screened to get the 56 who completed the study (25 males and 32 females). Of the 36 who were eliminated during, 22 did not meet the Edinburgh criteria and 14 failed the Dichotic Listening Task.

Design

The Edinburgh Handedness Inventory was administered first and those subjects who scored at or above the cut off level were then screened with the Dichotic Listening Task for Words. If the subject showed a right ear advantage on the Dichotic Word screen, random assignment was made to one of seven groups. Following this, the apparatus and procedure were explained and the data were collected. Each group consisted of eight subjects.

The first group received veridical EMG tonal biofeedback to the left ear (LE BFB) only while trying to reduce the level of arousal in the frontales muscles. The second group received veridical EMG tonal biofeedback to the right ear (RE BFB) only while trying to reduce the level of arousal in the frontales muscles. The third group received the biofeedback to both ears (BE BFB) while also trying to reduce frontales levels. The fourth group received relaxation tape input only to the left ear (RE RT). No biofeedback was provided but frontales EMG levels were monitored while the individual was listening to the relaxation tape. The fifth group received the relaxation tape to the right ear only (RE RT). The sixth group received the relaxation tape to both ears (BT RT). Like group four neither groups five nor six received biofeedback signals but did have their frontales EMG levels monitored while listening to the relaxation tape. The seventh group served as a control group (CONT) in that they were merely asked to sit quietly and try to relax. This group's EMG levels were also monitored and recorded.

All biofeedback and relaxation groups received the appropriate signals through stereo headphones capable of sending signals either to the left ear only, the right ear only, or to both ears. Headphones were also in place for the CONT group while data were collected but neither tonal biofeedback nor the relaxation tape was provided.

All groups received a five minute baseline period. After the baseline period, EMG levels were recorded and additional recordings were made at five minute intervals for 20 minutes.

Apparatus and Materials

Dichotic Words. The dichotic tapes were obtained from DK Consultants, London, Ontario, Canada. The tape consists of a series of paired words and has been prepared in such a manner that a different word is simultaneously presented to each ear (see Appendix B). There are 10 trials with each consisting of four word-pairs presented in succession. After each trial, the subject repeats what words were heard. At the completion of the 10 trials, the ear phones were reversed and the list was repeated. The score for each ear was the number of correct words repeated. To pass this screening, subjects had to recognize more words presented to the left ear than the right. The means and standard deviations for the number of correct words for each ear are given in Appendix D.

Edinburgh Handedness Inventory. This instrument is a brief and simple method of getting a highly stable quantitative assessment of handedness (McFarland & Anderson, 1980). On the Inventory, individuals indicated their degree of hand, eye, and leg preference as strong, weak, or none on each of the 12 items (see Appendix C). In calculating a laterality quotient, the sum of left hand preferences is subtracted from the sum of the right hand preferences. This remainder is then divided by the sum of the right and left hand preferences and multipled by 100. This quotient is then converted to a decile scoring. Only subjects with a Laterality Quotient of 68 were considered to have passed this aspect of the laterality screen. Means and standard deviations for these results are given in Appendix D.

Relaxation Tape. The tape was a 20 minute recording of ocean sounds and contained no verbal material. The tape was obtained from Health Associates, Dallas, Texas.

Stero Equipment. Koss model KC 180 stereo headphones were used for the dichotic word screen and the both ears BFB and RT experimental conditions. Pioneer model SE505 stereo headphones were used for the one ear BFB and RT conditions. The Pioneer headphones had individual ear volume adjustments that allowed the signal going to a particular ear to be turned off. The Koss headphones did not have this capability and were used in the screening and both ear conditions to assure as equal volume to each ear as possible. The dichotic and the relaxation tapes were presented through the earphones by a Sharp two-channel stereo cassette deck, model FT-10.

Biofeedback Equipment. Colbourn programmable modules were used. For the biofeedback groups, the machine provided a continuous tracking of levels of muscle action potentials for the forehead muscles. These subjects received immediate feedback in the form of a tone whose pitch varied with the level of muscle activity. The relaxation and control group's levels of EMG activity were recorded but not fed back to the subject. For all groups, a Colbourn R21-16 electromechanical printer furnished a record of EMG activity in microvolts averaged over the previous five minutes for each of the five five-minute intervals including baseline.

Procedure

The Edinburgh Handedness Inventory was administered and only those who achieved criteria on this instrument were given the Dichotic Listening Task for Words. If the subject was successful on the dichotic screening, random assignment was made to one of the seven experimental conditions. The handedness measure, dichotic screening, and data collection were all completed in the same session.

For the treatment phase, the subject was placed in a quiet, dimly lit room and seated in a comfortable chair. Each subject was informed as to which ear condition he would receive either the biofeedback tone or the relaxation tape. After the apparatus had been explained, three silver/silver chloride cap electrodes were attached to the forehead. Prior to electrode attachment, the forehead was rubbed with a cotton ball dampened with isopropyl alcohol. A reference electrode was placed midway between the hairline and eyebrows above the bridge of the nose. Active electrodes were placed one inch from either side of the reference electrode so that all three electrodes were in a horizontal line across the forehead. The electrodes were checked by a volt ohmmeter to insure that there was no impedence above 20,000 ohms between any two electrodes and that the impedence between any pairs of electrodes did not differ by more than 10,000 ohms.

For the biofeedback and relaxation tape groups, the feedback tone and tape loudness levels were adjusted and then turned off before taking the baseline measure. The headphones were left in place during the baseline period. After baseline, either the feedback tone or the tape was turned on and the session began. Headphones were also placed on the control group during baseline and while data was being collected. Frontales muscle levels were averaged over five minute periods and printed out on a Colbourn R21-16 electromechanical printer. As such a total of five readings were taken, one at the end of the five minute baseline and four additional ones at five minute intervals.

Biofeedback Groups. The procedure was similar to that described by Budzynski and Stoyva (1969). Subjects were told that they would be hearing a tone which indicated the degree of tenseness of their forehead muscles. They were instructed to use the tone to try to relax these muscles as much as possible. See Appendix E for specific instructions.

Relaxation Groups. The procedure for this group was similar to the one described by Miller and Bornstein (1977).

The subjects were asked to try to use the tape to help them relax in any manner they could. See Appendix F for specific instructions.

Control Group. This group was asked to sit quietly and try to relax the best way they could. See Appendix G for specific instructions. Electrode attachments and recordings were conducted in the same manner as the biofeedback and relaxation groups.

Results

A two-way, group by interval, analaysis of variance (ANOVA) was applied to microvolt change scores from baseline. The change scores were computed by subtracting the baseline microvolt level from the microvolt levels at each interval. Group refers to the seven experimental conditions (LE BFB, RE BFB, BE BFB, LE RT, RE RT, BE RT, and CONT). Interval refers to the times at which microvolt EMG difference scores were measured from baseline (5, 10, 15, and 20 minutes). The ANOVA demonstrated a significant group main effect, $F\ (6,49) = 3.91$, $p < .01$ and a significant group by interval interaction, $F\ (18, 147) = 1.7$, $p < .05$. The ANOVA summary table data are presented in Table 1. The means for microvoltchanges from baseline for each group across the four intervals are listed in Table 2 and are presented graphically in Figure 1.

Following the significant interaction, four one-way analysis of variance (ANOVA) on the difference scores at

Table 1

Analysis of Variance of Microvolt Changes From Baseline

Source of Variation	Sum of Square	df	Mean Square	F
Group	180.9696	6	30.1616	3.91**
Error	378.0982	49	7.7162	
Interaction	12.8854	18	.7158	1.70*
Error	61.7721	147	.4202	

*p < .05; **p < .01

Table 2

Microvolt Means for Changes from Baseline at Each Interval

	Interval			
Group	5 Minutes	10 Minutes	15 Minutes	20 Minutes
LE BFB	-2.5654	-2.6424	-2.9220	-3.1512
RE BFB	-0.0950	-0.2266	-0.1487	-0.3804
BE BFB	-0.7287	-1.1995	-1.6483	-1.8266
RE RT	-0.6933	-1.5654	-1.1045	-1.2654
LE FT	-0.3212	-0.5395	-0.5641	-0.6833
BE RT	-0.3304	-1.4529	-1.6145	-1.4250
CONT	-0.0879	-0.3454	-0.0845	-0.4062

each interval were computed. The ANOVA results for 5, 10, 15, and 20 minutes were F (6, 49) = 2.96, $p < .05$; F (6, 49) = 3.439, $p < .01$; F (6, 49) = 3.889, $p < .005$; and F (6, 49) = 3.979, $p < .005$ respectively. These ANOVA summary data are presented in Tables 3 through 6.

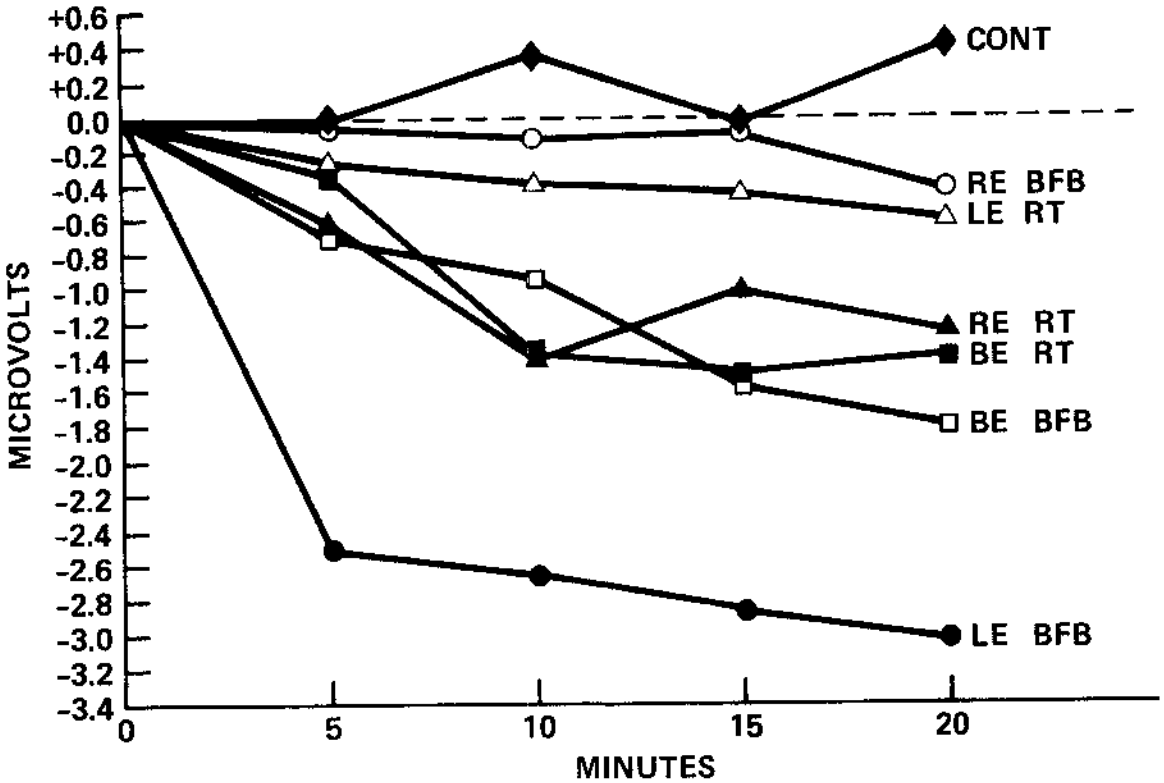

Figure 1. Microvolt change scores from baseline for each group.

The Newman-Keuls procedure was used to test differences among the means for each of four one way ANOVAs. At the end of five minutes, the LE BFB group differed significantly from all the other groups. At the end of 10 minutes, the LE BFB group was significantly different from the RE BFB and the CONT groups, but not from any of the others. At the end of 15 and 20 minutes, the LE BFB group was significantly different from the RE BFB, RE RT, and the CONT groups not from either of the BE groups or from the LE RT group. In summary, these analyses showed that afer five minutes, the LE BFB group was significantly superior in lowering EMG

Table 3

Analysis of Variance of Microvolt Change Scores After 5 Minutes

Source of Variation	Sum of Squares	df	Mean Square	F
Group	36.0040	6	6.0007	2.98
Error	98.4694	49	2.0096	

p < .05.

Table 4

Analysis of Variance of Microvolt Change Scores After 10 Minutes

Source of Variation	Sum of Squares	df	Mean Square	F
Group	46.9707	6	7.8284	3.43
Error	111.5344	49	2.2762	

p < .01.

Table 5

Analysis of Variance of Microvolt Change Scores After 15 Minutes

Source of Variation	Sum of Squares	df	Mean Square	F
Group	48.6971	6	8.1162	3.88
Error	102.2530	49	2.0868	

p < .005.

Table 6

Analysis of Variance of Microvolt Change Scores After 20 Minutes

Source of Variation	Sum of Squares	df	Mean Square	F
Group	62.1832	6	10.3639	3.97
Error	127.6135	49	2.6044	

$p < .005$.

levels from baseline than all groups. This group (LE BFB) also did significantly better in lowering EMG levels that the RE BFB and CONT groups across all intervals and was better than the RE RT group on all but the 10 minute interval.

An additional analysis on the EMG data was a three-way analysis of covariance (ANCOVA) using the baseline measure as the covariant. This was done to investigate any possible overall differences among the treatment and ear conditions when the biofeedback and relaxation tape groups were collapsed into three groups (left, right, and both). The 2 X 3 X 4 treatment by ear by interval ANCOVA showed biofeedback to be superior to relaxation tape input, F (1, 41) = 6.81, $p < .01$. There was also a significant ear effect, F (2, 41) = 4.87, $p < .01$ but no treatment by ear interaction, F (2, 41) = 1.35, p = 27. There was an overall interval effect, F (3, 126) = 9.86, $p < .0001$, but neither an interval by treatment nor interval by ear interaction; F (3, 126) =

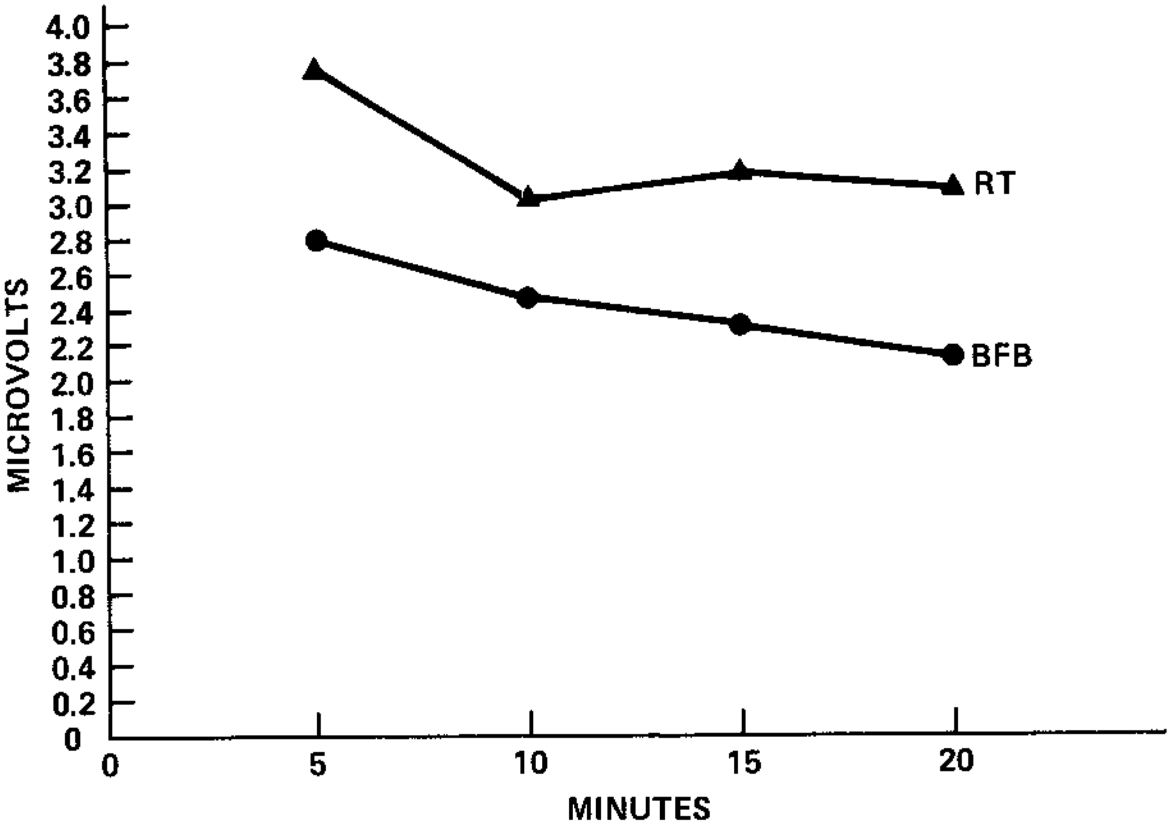

Figure 2. Microvolt levels adjusted from baseline and collapsed into biofeedback and relaxation tape groups.

1.62, p = 18 and F (6, 126) = 1.81, p = .10, respectively. The ANCOVA data are presented in Table 7. The adjusted microvolt means for the biofeedback and relaxation tape groups are presented graphically in Figure 2 and are listed in Table 8.

Because of the significant ear effect, the Newman-Keuls procedure was used to test the differences among the combined ear groups. The results of this analysis showed the left ear groups to be superior to the both ear group and to the right ear groups. Additionally, this showed the both ear groups to be superior to the right ear groups.

Table 7

Analysis of Covariance of Microvolt Scores
with Baseline as the Covariant

Source of Variation	Sum of Squares	df	Mean Square	F
Treatment	26.2509	1	26.2509	6.81*
Ear	37.5331	2	18.7665	4.87*
Treatment by Ear Interaction	10.3996	2	5.1998	1.35
Interval	12.3091	3	4.1030	9.98**
Interval by Treatment Interaction	2.0178	3	.6726	1.62
Interval by Ear Interaction	4.5290	6	.7548	1.81

*$p < .01$; **$p < .0001$.

Table 8

Adjusted Microvolt Levals Collapsed
into Treatment Conditions

	Interval			
Group	5 Minutes	10 Minutes	15 Minutes	20 Minutes
BFB	2.7196	2.4930	2.2762	2.0632
RT	3.6579	2.9203	3.0118	2.9817

The adjusted means for the combined ear groups are presented graphically in Figure 3 and are listed in Table 9.

The final statistical procedure compiles was a correlational analysis of the laterality screening measures; the Edinburgh Handedness Inventory and the Dichotic

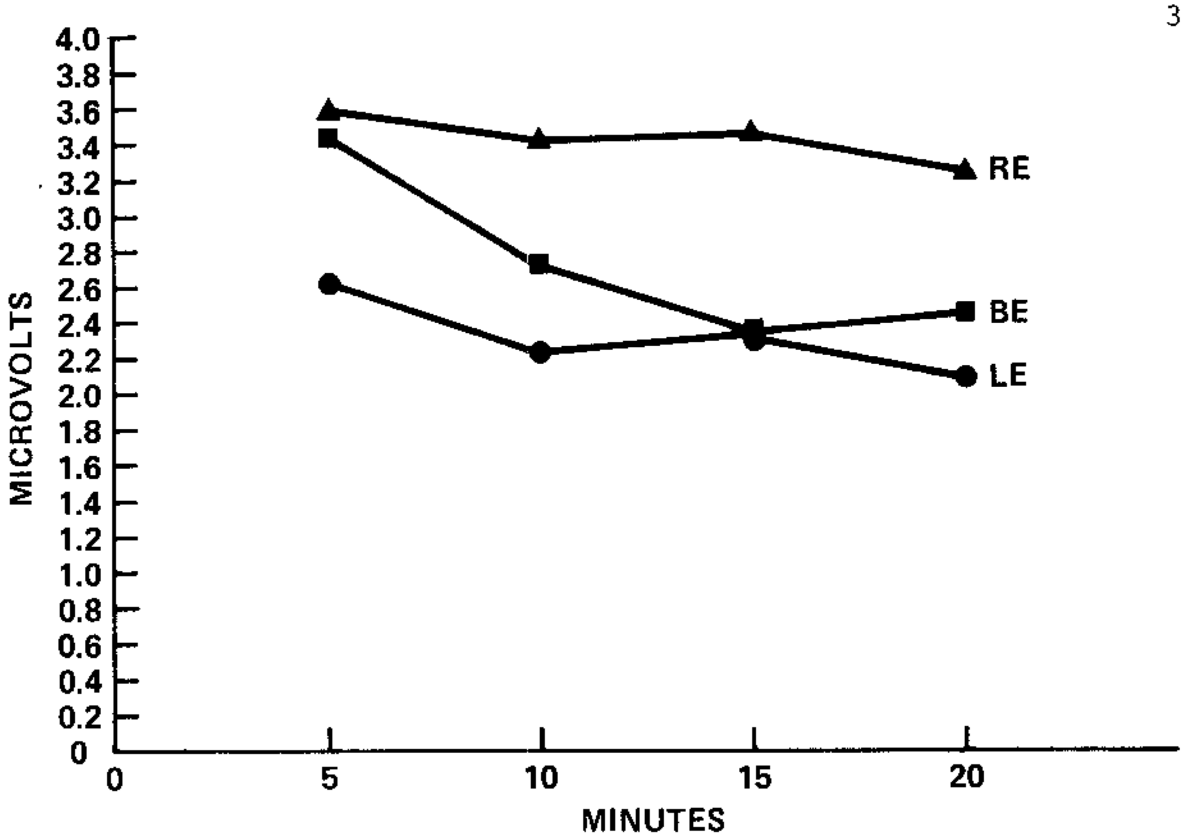

Figure 3. Microvolt levels adjusted from baseline and collapsed into left ear, right ear, and both ear groups.

Listening Task for Words. In order to be able to do this, the Dichotic Listening Task results were divided into three subsets of data for each subject. These were the number of words going to the right ear that were correctly identified, the number of words going to the left ear that were correctly identified, and the right ear correct minus left ear correct difference score. The means and standard deviations for the three sets of Dichotic Listening Task data and the Edinburgh Laterality Quotients are presented in Table 10, and the correlations with the associated probability values are listed in Table 11. Although none of

Table 9

Adjusted Microvolt Levels Collapsed Into Ear Conditions

	Intervals			
Group	5 Minutes	10 Minutes	15 Minutes	30 Minutes
LE	2.5900	2.1154	2.2060	2.0110
RE	3.5234	3.3484	3.3751	3.1997
BE	3.4529	2.6562	2.3510	2.5366

Table 10

Means and Standard Deviations for the Dichotic Listening Task for Words and Edinburgh Handedness Inventory

	Mean	Standard Deviation
Right Ear Correct	25.95	7.62
Left Ear Correct	10.04	4.63
Right-Left Difference	15.91	9.65
Edinburgh	85.41	11.45

Table 11

Edinburgh by Dichotic Words Correlations

	RE Words	LE Words	Words Diff.
Edinburgh	0.1616 p=.117	-.1706 p=104	0.2096 p=.061

The correlations reached significance, the highest seen was the handedness measure with the word difference score.

Discussion

One specific and two general conclusions can be drawn from these data. The first general conclusion is that in a population of right handed individuals with a right ear advantage for the recognition of dichotically presented words, electromyographic biofeedback is superior to a non-verbal, non-instructional relaxation tape in producing a lowering of forehead muscle tension. The second general conclusion is that, in this restricted population, there is a differential effect of left versus right versus both ear(s) input in producing a reduction in forehead muscle tension levels. The particulars are that left ear input is superior, both ears input is intermediate, and right ear input is least effective. The specific conclusion drawn from these data is that the Left Ear Biofeedback group was superior to the Right Ear Biofeedback and Control groups across all intervals in lowering frontales EMG levels. An additional observation noted as an item of interest is the somewhat surprising lack of correlation among the treatment conditions, the measure of handedness, and the dichotic words task.

The first general conclusion of this study, that the combined biofeedback groups were significantly superior to the combined relaxation tape groups, is contradictory to many who have suggested that there are no differences between the two approaches in their efficiency as relaxation techniques (e.g., Miller, 1982; Alexander & Smith, 1979). The current findings lend support to the claim made by Qualls and Sheehan (1981) that additional data is needed on the variables that may influence frontales EMG biofeedback performance before a final judgement can be made concerning its efficacy as a viable relaxation technique.

Several points need to be considered in comparing the current data with other biofeedback and relaxation training investigations. The first is that because this was a one session study, nothing can be said about any differential practice effects with biofeedback versus relaxation training over a period of time. Also, the tape (which consisted of ocean sounds) that was used in the present study was not an instructional relaxation tape, an imagery tape, or a progressive relaxation tape. An additional limitation is that only EMG measures considered to represent frontales muscle tension levels were monitored. Neither subjective ratings of arousal levels nor other physiological measures were taken either before or after the biofeedback and relaxation tape sessions. Related to this is that the subjects in the current study were normal, intact individuals and not persons who were reporting high levels of stress. Another restriction is that these results only apply to a strongly right handed population who correctly reported more dichotically presented words to the right ear than to the left.

With few exceptions, the most common method that has been used when either comparing biofeedback with some form of relaxation training technique or when investigating various forms of biofeedback has been to provide the feedback signal to both ears. In the present study, seven different ear input conditions were evaluated and although the BE BFB group showed a greater magnitude of EMG decrease from baseline across all intervals than did the BE RT group (see Figure 1), none of these differences were significant. That is, with the typical method of ear input, the BE BFB group was not statistically different from the BE RT group at any interval. To repeat, only when the biofeedback and relaxation tape groups were collapsed into two conditions did the differences between the methods reach significance. However, the results of the combined biofeedback and relaxation tape groups and of the seven separate experimental conditions do offer some basis for speculation as to what variables may influence biofeedback performance. Certainly, the current findings do not support the claim of Alexander and Smith (1979) that EMG biofeedback has no unique or nonunique properties of interest.

In summary, the biofeedback and relaxation tape conclusions of this study may not apply when comparing these relaxation training methods over an extended period of time, when making comparisons among clinical populations, and when comparing this form of biofeedback to other types of relaxation tape input. However, in regard to the last point, it has been demonstrated that listening to soothing music somewhat similar to the sounds on the current tape can be as effective in lowering frontales EMG levels as guided imagery and progressive relaxation (Miller & Bornstein, 1977).

The second general conclusion of this study is that (in this restricted population) there are differential effects of ear(s) input in producing a reduction of forehead muscle tension levels. That is, lateralized input can have a significant effect during a behaviorally complicated task in normal, intact individuals. When input conditions are collapsed into ear groups (left ear, both ears, and right ear), significant differences are found among all comparisons. In attempting to account for these findings, four very broad possibilities are considered.

The first is that the ear effects may be a function of which hemisphere is receiving the majority of the initial input. A second interpretation is that one hemisphere may be more efficient in processing the biofeedback signal and the relaxation tape input. The third possibility is that one hemisphere may preferentially regulate output to the frontales muscles. The fourth explanation for these findings is that some combination of these three variables (input, processing, and output) may be responsible for the present results.

With the first explanation, the important consideration is which hemisphere is receiving the majority of the stimuli. When collapsed across ear conditions, the group showing the greatest amount of decrease in EMG levels was the one receiving the biofeedback and relaxation tape input to the left ear (right hemisphere) and the group showing the least decrease received the input to the right ear (left hemisphere). The both ears group were intermediate, as overall they were less effective than the LE group but more effective than the RE group in lowering EMG levels. To emphasize, this pattern of ear differences was significant only when the groups were collapsed into ear input conditions for overall comparisons.

With the exception of the CONT group, the two individual groups that showed the least amount of decrease in EMG levels were the RE BRB and LE RT conditions. That is, the relaxation tape input to the right hemisphere did not facilitate a lowering of EMG levels. This is not consistent with an explanation that the majority of the initial input going to the right hemisphere is the most important variable in accounting for the overall EMG changes. This explanation also loses some of its saliency when the nature of the signals are considered. Both the biofeedback tone and the relaxation tape consisted of non-verbal material; the most common dichotomy that has been ascribed to hemispheric specialization of function has been that of a verbal left hemisphere versus a non-verbal right hemisphere (Bradshaw & Nettleton, 1981). This raises the question that the type of input as well as the hemisphere of input may be crucial. Such an interaction suggests that it is not simply where input is going that is crucial but that there may also be some manner in which the input stimulus is processed that warrants consideration.

This second explanation raises the possibility that one of the hemispheres is more efficient in processing the biofeedback signal and the relaxation tape input. In the current study, input going primarily to the right hemisphere may be "uncoupling" stress, as attending to the tone aids the right hemisphere to be less aroused. Support for this are the claims that the right hemisphere is more actively involved in the experiencing of emotion (Bryden, Ley, & Sugerman, 1982; Ley & Bryden, 1982) and that there is greater right hemisphere activation during stress (Tucker et al., 1977). The intermediate results of the both ears condition can may apply here as these results would also be consistent with Denenberg's concepts of an interhemispheric coupling coefficient and interhemispheric inhibition (1981). That is, the efficiency of both hemispheres can be intermediate to the workings of the individual hemispheres if one is highly specialized for a particular function.

The third explanation is that one hemisphere may be superior in regulating output to the frontales muscles. Support for this comes from findings that the left hemisphere is more accurate in tracking with a cursor when the cursor tone was being presented to the left ear while the target tone was being presented to the right ear

(Susman et al., 1978, 1979). This would be especially relevant for the LE BFB conditions where the left hemisphere may be actively trying to lower ongoing motor activity to match the biofeedback tone. This would be somewhat at odds with the suggestion that the right motor cortex is more involved than the left in cortically directed nonverbal facial movement (Ekman et al., 1981).

The fourth explanation is that the results are due to some combinations of input, processing, and output variables. When the base line period is included, the total time for which data was gathered was for 25 minutes. This in itself would seem to negate a single system explanation for the results. Also, that some combination of factors is the most salient explanation is apparent from the discussions of the other three as there is no single process that can account for the combined ear and treatment results or for the data for the seven individual groups.

One way to view these results is that, contrary to other specualtions, the left hemisphere is more involved in relaxation than the right. In the RE conditions, input to the left hemisphere may be interfering with its ability to relax. That is, the left hemisphere is trying to do two things at once; attend to the signal and lower arousal. The specifics of how systems can interfere with each other can be explained by the functional distance principle which postulates that separate neural control centers which are functionally close together will conflict if they are independently engaged in unrelated activity (Kinsborne, 1982). The basis for this is that highly connected areas lend themselves to successive rather than simultaneous use of information. With this in mind (the left hemisphere being more involved in the lowering of arousal) input to the right hemisphere allows the left hemisphere to work more efficiently. That is, while the right hemisphere is tracking the signal, the left hemisphere is doing whatever is necessary to lower EMG levels.

The LE BFB may be the most efficient in getting the left anterior areas involved in relaxing the frontales. With this condition there is maximal neural distance so input would not be interfering with output. What may be happening is successive listening and changing the tension in the muscles and not simultaneous listening and manipulating the tone. This is very consistent with the notion of adjacent areas working best at the serial processing of information. The right posterior is attending to and tracking the one and the left anterior is using this information to maximally effect output to the frontales. That the varying tone to the right hemipshere is being used by the left to monitor frontales levels would also be consistent with Sussman's findings. Information that may provide additional understanding of these and other biofeedback data might be gained by providing a low pitch tone in either the left or right ear and the EMG biofeedback tone to the opposite ear. The task would be to try to match the biofeedback tone to the constant.

What must be recognized when trying to evaluate the combined ear and signal effects, are differences that were not seem among the seven separate groups. It was the LE BFB group that provided the differences that were seen among these experimental conditions in lowering EMG levels. This group was superior to all others after five minutes which suggest that initial input may have had a significant effect. However, after 10 minutes the LE BFB continued to be significantly superior only to the RE BFB and CONT groups. At the end of 15 minutes, the LE BFB group was different from the LE RT, the RE BFB, and the CONT groups. This pattern was also seen at the end of 20 minutes. Conversely, at 10, 15, and 20 minutes the LE BFB was not different from RE RT, BE RT, or BE BFB. Also, at no time were there any differences among the LE RT, RE RT, BE RT, RE BFB and BE BFB groups. This illustrates that caution needs to be exercised to avoid over emphasizing differences noted when the treatment and ear groups were collapsed for comparisons. However, the results do imply that laterality of input has a significant effect in a behaviorally complicated situation in normal intact individuals.

The current results differ from the two previous studies of differential ear input during biofeedback tasks

(Greenstadt et al., 1978; Suter, 1980). There are several differences between the present method of investigation and these earlier works. Both of these used self-report of handedness as their only measure of laterality. The criteria for peripheral laterality was more stringent in the present study as 23.9% (22 of 92) of the right-handed individuals screened failed to meet the standard for handedness as measured by the Edinburgh, and 20% (14 of 70) who passed the Edinburgh failed the dichotic screen. Also both of the earlier studies were trying to influence behaviors that may be more under the control of the autonomic nervous system than are fontales EMG levels. The pathways from central nervous system (CNS) input (audible clicks or tone) to autonomic output (heart beat or temperature change) may be much more complex than CNS input (audible tone) to CNS output (changes in somatic muscle tension). However, an explanation for Greenstadt et al. can be offered based on the current findings. Their feedback consisted of a discrete click that sounded whenever the heartbeat rate was above criteria and they report that the greatest magnitude of increase was when the tone was presented to the right ear. Heart rate is generally accompanied by arousal. Based on the model presented earlier, the Greenstadt results could be seen as very similar to the RE BFB condition which (except for the CONT group) produced the least amount of lowering of EMG levels.

The left posterior was attentive because stimuli was coming in at varying intervals and the clicks were augmenting an aroused situation.

The lack of a strong correlation between the handedness inventory and any of the dichotic words subsets suggests that individuals who are strongly lateralized by one measure may not necessarily be lateralized by another. The data raises questions about the validity of considering laterality as a unitary concept and argues against the idea of making conclusions about the lateralization of brain function based on a single measure.

Strictly on a speculative basis, the failure of the CONT group to show decreases in EMG levels may be viewed as being consistent with rCBF studies that have reported hyperprofusion in frontal areas during rest (Mamo et al., 1983). The suggestion offered is that just because normal individuals are sitting queitly does not mean that they are at rest or that active planning may not be taking place. This leads to an additional speculation regarding a possible mechanism for biofeedback or relaxation training, i.e. that some of the effectiveness of these techniques may be due to a disruption of hyperfrontal levels of arousal. Hyperstressed individuals may be hyperfrontal and need directed lowered arousal. Asking such individuals to "just sit and relax" may actually be increasing their levels of stress. It must be emphasized that these suggestions are offered simply as speculations. However, it would appear worthwhile to compare rCBF and frontales EMG biofeedback data of normal and highly stressed populations.

Appendix A

Form 2

USE OF HUMAN SUBJECTS

INFORMED CONSENT

NAME OF SUBJECT: ______________________________

1. I hereby give consent to ____________ to perform or supervise the following investigational procedure or treatment:

   Edinburgh Handedness Inventory, Dichotic Listening Task for Words, Relaxation Training, and Biofeedback Training

2. I have (seen, heard) a clear explanation and understand the nature and purpose of the procedure or treatment; possible alternate procedures that would be advantageous to me (him, her); and the attendent discomforts or risks involved and the possibility of complications which might arise. I have (seen, heard) a clear explanation and understand the benefits to be expected. I understand that the procedure or treatment to be performed is investigational and that I may withdraw my consent for my (his, her) status. With my understanding of this, having received this information and satisfactory answers to the questions I have asked, I voluntarily consent to the procedure or treatment designated in Paragraph 1 above.

____
Date

SIGNED: ______________________ SIGNED: ______________________
Witness Subject

or

SIGNED: ______________________ SIGNED: ______________________
WITNESS Person Responsible

____
Relationship

Instructions to persons authorized to sign:

If the subject is not competant, the person responsible shall be the legal appointed guardian or legally authorized representative.

If the subject is a minor under 18 years of age, the person responsible is the mother or father or legally appointed guardian.

If the subject is unable to write his name, the following is legally acceptab;e: John H. (His X Mark) Doe and two (2) witnesses.

Appendix B

DIRECTIONS - DICHOTIC WORDS

Apparatus: Stereophonic tape recorder with earphones and a dichotic tape with sets of words on it.

Directions: Turn on the tape recorder at least 5 minutes before playing the tape. Check the volume balance on several items with the earphones in both the normal (N) and reversed (X) positions. The normal position is that in which the words arriving at the subjects right ears are those listed under RIGHT channel of the response sheet. Subjectively equate the volume of the two channels. You must reverse earphones at least once to do this because most people have a right-ear bias. Instruct the subject that he will be wearing headphones.

Say, "You are going to hear different words coming to the two ears at the same time, for example, house in this ear (point) and gown in the other ear (point). You are going to hear several pairs of different words. When the voice stops, tell me all the words you heard, in any order you like. Guess at them if you are not sure. Remember, listen to both ears, and as soon as the voice stops, call out all the words you can."

Place the earphones directly over the ears of the subject. Start with the practice trial (3 items per ear). Ensure that volume levels are adequate. After the practice trial, stop the tape recorder and say, "Now you will hear four different pairs of words in each ear, 8 words all together. Try to call out as many as you can immediately after the voice stops." Play the tape continuously through the 10 trials, if possible. Remind each subject, "Say the words as quickly as you can, as soon as the voice stops so that you don't forget them." Make sure the subject does not engage in extraneous comments, thus missing a presentation. The tape may be stopped between trials. Do not replay missed segments.

After the first presentation, reverse the earphone positions and run the test again.

Recording: Note on the response sheet the position of the earphones (N or X) and the order of presentation (i.e. 1-1st, 2-2nd, etc. . .).

Scoring: There are 4 words presented to each ear on each of 10 trials, making a maximum score of 40 per ear. Total the number of correct responses for the left ear and right ear in both the normal and reversed conditions. To be included in the study, subjects must show a right ear advantage by having more correct right responses than left.

DICHOTIC WORDS

NAME:______________________ SEX:_____ AGE:_____ DATE:________

EARPHONES - NORMAL (N) EARPHONES - REVERSED (X)

	LEFT								
P.	can	____	pal	____	P.	pal	____	can	____
	pick	____	fit	____		fit	____	pick	____
	win	____	rim	____		rim	____	win	____
1.	main	____	rail	____	1.	rail	____	doll	____
	keep	____	wheat	____		wheat	____	keep	____
	run	____	come	____		come	____	run	____
	could	____	book			book		could	____
2.	rock	____	top	____	2.	top	____	rock	____
	week	____	feel	____		feel	____	week	____
	tin	____	pill	____		pill	____	tin	____
	sad	____	have	____		have	____	sad	____
3.	red	____	wet	____	3.	wet	____	red	____
	bid	____	pig	____		pig	____	bid	____
	hack	____	lag	____		lag	____	hack	____
	doll	____	brought	____		brought	____	doll	____
4.	lap	____	rag	____	4.	rag	____	lap	____
	dig	____	pit	____		pit	____	dig	____
	bug	____	mud	____		mud	____	bug	____
	fawn	____	wall	____		wall	____	fawn	____
5.	ham	____	ran	____	5.	ran	____	ham	____
	pod	____	fog	____		fog	____	pod	____
	dip	____	big	____		big	____	dip	____
	fun	____	rum	____		rum	____	fun	____
6.	rot	____	mop	____	6.	mop	____	rot	____
	pin	____	dim	____		dim	____	pin	____
	cup	____	but	____		but	____	cup	____
	meek	____	neat	____		neat	____	meek	____
7.	rug	____	bud	____	7.	bud	____	rug	____
	cab	____	gap	____		gap	____	cab	____
	beam	____	keen	____		keen	____	beam	____
	lid	____	mitt	____		mitt	____	lid	____
8.	hum	____	ton	____	8.	ton	____	hum	____
	mail	____	rain	____		rain	____	mail	____
	nap	____	bat	____		bat	____	nap	____
	dot	____	log	____		log	____	dot	____

9.	bin	_____	will	_____	9. will	_____	bin	_____
	fan	_____	tam	_____	tam	_____	fan	_____
	tuck	_____	love	_____	love	_____	tuck	_____
	bet	_____	den	_____	den	_____	bet	_____
10.	bomb	_____	gone	_____	10. gone	_____	bomb	_____
	hat	_____	map	_____	map	_____	hat	_____
	peel	_____	bean	_____	bean	_____	peel	_____
	rib	_____	tip	_____	tip	_____	rib	_____
	Correct	___	Correct	_____	Correct	_____	Correct	___

Total Right Correct _____

Total Left Correct _____

Appendix C

Edinburgh Handedness Inventory

Name:______________________________ Date:__________________

Age:_______________________________ Sex:___________________

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

Some of the activiites requie 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 of 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 eye?	_____	_____

Edinburgh Laterality Quotients and Decile Values: Right

Laterality Quotients	Decile Values
48	1
60	2
68	3
74	4
80	5
84	6
88	7
92	8
95	9
100	10

Appendix D

Means and Standard Deviations for the Dichotic Listening Task for Words and the Edinburgh Handedness Inventory

Measure	Mean	Standard Deviation
Dichotic Words - Right Ear Correct	25.95	7.62
Dichotic Words - Left Ear Correct	10.04	4.63
Edinburgh Laterality Quotient	85.41	11.45

Appendix E

Biofeedback Groups Instructions

Both Ears

"Please sit quietly for five minutes. At the end of this time, you will begin to hear the tone. When you hear the tone, try to relax as much as possible. The more you relax, the lower the tone will be. Try to keep the tone as low as you can by relaxing for the remainder of the session."

Left and Right Ears

PLease sit quietly for five minutes. At the end of this time you will begin to hear the tone. You will hear the tone in only one ear. Do not be concerned abou this. When you hear the tone, try to relax as much as possible. The more you relax the lower the tone will be. Try to keep the tone as low as you can by relaxing for the remainder of the session."

Appendix F

Relaxation Tape Groups Instructions

Both Ears

"Please sit quietly for five minutes. At the end of this time, you will hear the tape. When you hear the tape, try to relax as much as possible for the remainder of the session."

Left and Right Ears

"Please sit quietly for five minutes. At the end of this time, you will hear the tape in only one ear. Do not be concerned about this. When you hear the tape, try to relax as much as possible for the remainder of the session."

Appendix G

Control Group Instructions

"Please sit quietly for five minutes. At the end of this time, I will ask you to try to relax as much as possible for the remainder of the session."

References

Ahern, G. L., & Schwartz, G. E. (1979). Differential lateralization for positive versus negative emotions. Neuropsychologia, 1979, 17, 693-698.

Alexander, A. B., & Smith, D. D. (1979). Clinical applications of EMG biofeedback. In R. J. Gatchel and K. P. Price (Eds.), Clinical applications of biofeedback: Appraisal & Status. New York: Pergamon Press

Allen, M. (1983). Models of hemispheric specialization. Psychological Bulletin, 93, 73-104.

Ariel, R. N., Golden, C. J., Berg, R. A., Quaife, M. A., Dirkson, J. W., Wilson, J., Graber, B. (1983). Regional cerebral blood flow in schizophrenics. Archives of General Psychiatry, 40, 258-263.

Bensen, H., Shapiro, D., Tursky, B., & Schwartz, G. (1971). Decreased systolic blood pressure through operant conditioning techniques in patients with essential hypertension. Science, 173, 740-742.

Berlin, C. I. (1977). Hemispheric asymmetry in auditory task. In S. Harnad, R. W. Doty, L. Goldstein, J. Jaynes, and G. Krauthamer (Eds.), Lateralization in the nervous system. New York: Academic Press.

Blanchard, E. B., & Haynes, R. M. (1975). Biofeedback treatment of Raynaud's disease. Journal of Behavior Therapy and Experimental Psychiatry, 6, 230-234.

Bradshaw, J. L., & Nettleton, N. C. (1981). The nature of hemispheric specialization in man. The brain and behavioral sciences, 4, 51-91.

Broadbent, D. E., & Gregory, M. (1964). Accuracy of recognition for speech presented to the right and left ears. Quarterly Journal of Experimental Psychology, 16, 359-360.

Brundely, J. (1982). Biofeedback in chronic neurological cases: Therapeutic electromyography. In L. White and B. Trusky (Eds.), Clinical Biofeedback: Efficacy and Mechanisms. New York: Guilford Press.

Bryden, M. P. (1982). Laterality: Functional asymmetry in the intact brain. New York: Academic Press.

Bryden, M. P., Lay, R. G., & Sugarman, J. H. (1982). A left-ear advantage for identifying the emotional quality of tonal sequences. Neuropsychologia, 20, 83-87.

Buchsbaum, M. S., & Ingvar, D. H. (1982). New visions of the schizophrenic brain: Regional differences in electrophysiology; blood flow, and cerebral glucose use. In F. A. Henn and H. A. Nasrallah (Eds.), Schizophrenia as a brain disease. New York: Oxford University Press.

Budzynski, T. H., & Stoyva, J. M. (1969). An instrument for producing deep muscle relaxation by means of analog information feedback. Journal of Applied Behavior Analysis, 2, 231-237.

Cohen, G. (1973). Hemispheric differences in serial versus parallel processing. Journal of Experimental Psychology, 97, 349-356.

Corballis, M. C., & Beale, I. L. (1976). The psychology of left and right. Hillsdale, N. J.: Lawrence Erlbaum Associates.

Davidoff, J. B., Done, J., & Scully, J. (1981). What does the lateral ear advantage relate to? Brain and Language, 12, 332-346.

Denenberg, V. H. (1981). Hemispheric laterality in animals and the effects of early experience. The brain and behavioral sciences, 4, 1-49.

DeRenzi, E. (1982). Disorders of space exploration and cognition. New York: John Wiley & Sons.

Dimond, S. J., & Blizard, D. A. (Eds.) (1977). Evolution and lateralization of the brain. Annals of the New York Academy of Science, 299.

Ekman, P., Hager, J. C., & Friesen, W. V. (1981). The symmetry of emotional and deliberate facial actions. Psychophysiology, 18, 101-106.

Franzen, G., & Ingvar, D. H. (1975). Abnormal distribution of cerebral activity in chronic schizophrenics. Journal of Psychiatric Research, 12, 199-214.

Gatchel, R. J. (1979). EMG biofeedback in anxiety reduction. In L. White and B. Trusky (Eds.), Clinical biofeedback: Efficacy and Mechanisms. New York: Guilford Press.

Gatchel, R. J., & Price, K. P. (1979). Biofeedback: An introduction and historical overview. In R. J. Gatchel and K. P. Price (Eds.), Clinical applications of biofeedback: Appraisal & status. New York: Pergamon press.

Gatchel, R. J., Korman, M., Weiss, C. B., Smith, D., & Clark, L. A. (1978). Multiple-response evaluation of EMG biofeedback performance during training and stress-induction conditions. Psychophysiology, 15, 253-259.

Gazzaniga, M. S., Bogen, J. E., & Sperry, R. W. (1963). Laterality effects in somesthesis following cerebral commissurotomy in man. Neuropsychologia, 1, 209-221.

Geschwind, N., & Levitsky, W. (1968). Human brain: Left-righ asymmetries in temporal speech region. Science, 161, 186-187.

Greenstadt, L., Schuman, M., & Shapiro, D. (1978). Differential effects of left versus right monoral biofeedback for heart rate increases. Psychophysiology, 15, 233-238.

Gur, R. C., Packer, I. K., Hungerburger, J. P., Reivich, M., Obrist, W. D., Amarnek, W. S., & Sackeim, H. A. (1980). Differences in distribution of gray and white matter in human cerebral hemispheres. Science, 207, 1226-1228.

Haynes, S. N., Griffin, P., Mooney, D., & Parise, M. (1975). Electromyographic feedback and relaxation instructions in the treatment of muscle contraction headache. Behavior Therapy, 6, 672-678.

Hicks, R. E., Bradshaw, G. J., Kinsborne, M., & Feigin, D. S. (1978). Vocal-manual trade-offs, in hemispheric sharing of human performance control. Journal of Motor Behavior,

Ingvar, D. H. (1976). Functional landscapes of the dominant hemisphere. Brain Research, 197, 181-197.

Kimura, D. (1961). Cerebral dominance and the perception of verbal stimuli. Canadian Journal of Psychology, 15, 166-171.

Kimura, D. (1967). Functional asymmetry of the brain in dichotic listening. Cortex, 3 , 163-178.

Kinsborne, M. (1982). Hemispheric specialization and the growth of human understanding. American Psychologist, 37, 411-420.

Lee, R. M., Baldwin, S. E., & Lee, J. A. (1977). Clinical uses of biofeedback: A review of recent research. Henry Ford Hospital Medical Journal, 25, 99-118.

Le Doux, J. E., Wilson, D. H., & Gazzaniga, M. S. (1977). Manipulo-spatial aspects of cerebral lateralization: Clues to the orgin of lateralization. Neuropsychologia, 15, 743-750.

LeMay, M. (1976). Morophological cerebral asymmetries of modern man, fossil man, and nonhuman primates. Annals of the New York Academy of Science, 280, 249-366.

Ley, R. G., & Bryden, M. P. (1982). A dissociation of right and left hemisphere effects for recognizing emotional tone and verbal content. Brain and Cognition, 1, 3-9.

Lubar, J. F., & Bahler, W. W. (1976). Behavioral management of epileptic seizures following EEG biofeedback training of the sensorimotor rhythm. Biofeedback and Self-Regulation, 1, 77-104.

Mamo, H., Meric, P., Luft, A., & Seylaz, J. (1983). Hyperfrontal pattern of human cerebral circulation. Archives of Neurology, 40, 626-632.

McFarland, K. Anderson, J. (1980). Factor stability of the Edinburgh Handedness Inventory as a function of test-retest performance, age, and sex. British Journal of Psychology, 71, 135-142.

McGlone, J. (1980). Sex differences in human brain asymmetry: A critical survey. The Brain and Behavioral Sciences, 3, 215-263.

Miller, N. (1982). Some directions for clinical and experimental research on biofeedback. In L. White and B. Trusky (Eds.), Clinical biofeedback: Efficacy and mechanisms. New York: Guilford Press.

Miller, R. K., & Bornstein, P. H. (1977). Thirty-minute relaxation: A comparison of some methods. Journal of Behavioral Therapy and Experimental Psychiatry, 8, 291-294.

Millar, J. M., & Whitaker, H. A. (1983). The right hemisphere's contribution to language. A review of the evidence from brain damaged subjects. In S. J. Segalowitz (Ed.), Language functions and brain organization. New York: Academic Press.

Mononel, L. J., & Seitz, M. R. (1977). An AER analysis of contralateral advantage in the transmission of auditory information. Neuropsychologia, 15, 165-173.

Moscovitch, M., & Olds J. (1982). Asymmetries in spontaneous facial expressions and their possible relation to hemisphereic specialization. Neuropsychologia, 20, 71-81.

Nasrallah, H. A. (1982). Laterality and hemipsheric dysfunction in schizophrenia. In F. A. Henn and H. A. Nasrallah (Eds.) Schizophrenia as a brain disease. New York: Oxford University Press.

Nebes, R. D. (1978). Direct examination of cognitive function in the right and left hemispheres. In M. Kinsborne (Ed.) Asymmetrical function of the brain. New York: Cambridge Press.

Obrzut, J. E., Hynd, G. W., Obrzut, A., & Pirozzolo, F. J. (1981). Effects of directed attention on cerebral asymmetries in normal and learning disabled children. Developmental Psychology, 17, 118-125.

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

Qualls, P. J., & Sheehan, P. W. (1981). Electromyograph feedback as a relaxation technique: A critical appraisal and reassessment. Psychological Bulletin, 90, 21-42.

Ross, E. D. (1981). The aprosodias. Functional-anatomic organization of the affective components of language in the right hemipshere. Archives of Neurology, 38, 561-569.

Rosenzweig, M. R. (1951). Representations of the two ears at the auditory cortex. American Journal of Physiology, 167, 147-214.

Rubens, A. B. (1977). Anatomical asymmetries of human cortex. In S. Harnad, R. W. Doty, L. Goldstein, J. Jaynes, and G. Krauthamer (Eds.), Lateralization in the nervous system. New York: Academic Press.

Sackeim, H. A., Greenberg, M. S., Weiman, A. L., Gur, R. C., Hungerbuhler, J. P., & Geschwind, N. (1982). Hemispheric asymmetry in the expression of positive and negative emotions. Archives of Neurology, 39, 210-218.

Sargent, J. D., Green, E. E., & Walters, E. D. (1973). Preliminary report on the use of autogenic feedback training in the treatment of migraine and tension headaches. Psychosomatic Medicine, 35, 129-135.

Satz, P. (1968). Lateralioty effects in dichotic listening. Nature, 218, 277-278.

Schulman-Galambos, C. (1977). Dichotic listening performance in elementry and college students. Neuropsychologia, 15, 577-584.

Searleman, A. (1977). A review of right hemipshere linguistic capabilities. Psychological Bulletin, 84, 503-528.

Segalowitz, S. J. (1983). Language functions and brain function. New York: Academic Press.

Seidman, L. J. (1983). Schizophrenia and brain dysfunction: An integration of recent neurodiagnostic findings. Psychological Bulletin, 94, 195-238.

Semmes, J. (1968). Hemispheric specialization: A possible clue to mechanism. Neuropsychologia, 6, 11-26.

Shanon, B. (1980). Lateralization effects in musical decision tasks. Neuropsychologia, 18, 21-31.

Shapiro, D., & Schwartz, G. (1972). Biofeedback and bisceral training: Clinical applications. Seminars in Psychiatry, 2, 171-184.

Silver, B. V., & Blanchard, E. B. (1978). Biofeedback and relaxation training in the treatment of psychophysiological disorders: Or are the machines really necessary? Journal of Behavioral Medicine, 1, 217-239.

Springer, S., & Deutch, G. (1981). Left brain, right brain. San Francisco: W. H. Freeman.

Stoudenmire, J. A. (1975). A comparison of muscle relaxation training and music in the reduction of state and trait anxiety. Journal of Clinical Psychology, 31, 490-492.

Sussman, H. (1971). The laterality effect in lingual-auditory tracking. Journal of the Acoustical Society of America, 49, 1874-1880.

Sussman, H. (1979). Evidence for left hemipshere superiority in processing movement-related tonal signals. Journal of Speech and Hearing Research, 22, 224-235.

Sussman, H., & MacNeilage, P. F. (1975). Studies of hemispheric specialization for speech production. Brain and Language, 2, 131-151.

Sussman, H., & Westbury, J. R. (1978). A laterality effect in isometric and isotonic labial tracking. Journal of Speech and Hearing Research, 21, 563-579.

Suter, S. (1980). Left versus right monaural biofeedback for finger temperature changes. Perceptual and Motor Skills, 50, 70.

Townsend, R. E., House, J. F., & Addario, D. (1975). A comparison of EMG feedback and progressive muscle relaxation training in the treatment of anxiety neuroses. American Journal of Psychiatry, House & Addario.

Tucker, D. M., Roth, R. S., Arneson, B. A., & Buckingham, V. (1977). Right hemisphere activation during stress. Neuropsychologia, 15, 697-700.

Walsh, K. (1978). Neuropsychology, a clinical approach. New York: Churchill Livingstone.

Weiss, T., & Engel, B. T., (1971). Operant conditioning of heart rate in patients with premature ventricular contractions. Psychosomatic Medicine, 33, 301-321.

Wexler, B. E. (1980). Cerebral laterality and psychiatry: A review of the literature. American Journal of Psychiatry, 137, 279-291.

White, M. J., & White, K. G. (1975). Parallel-serial processing and hemispheric function. Neuropsychologica, 13 , 377-381.

Witelson, S. F. (1983). Bumps on the brain. Right-left asymmetry as a key to functional lateralization. In S. J. Segalowitz (Ed.), _Language functions and brain organization_. New York: Academic Press.

Yandell, L., & Elias, J. W. (1983). Left hemispheric advantage for a visuospatial-dihaptic matching task. _Cortex_, _19_, 69-78.