1980

Hemispheric asymmetries in faculty and student musicians and nonmusicians during melody recognition tasks : a thesis ...

Mark T. Wagner
University of the Pacific

Hemispheric Asymmetries in Faculty and Student Musicians and Nonmusicians During Melody Recognition Tasks

A Thesis

Presented to

the Graduate Faculty of the

University of the Pacific

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

by

Mark T. Wagner

March, 1980

This thesis, written and submitted by

Mark Todd Wagner

is approved for recommendation to the Committee on Graduate Studies, University of the Pacific.

~~Department Chairman or Dean:~~

____

Thesis Committee:

________________________________ Chairman

____

____

____

____

Dated ________________________________

Acknowledgement

The author wishes to extend thanks to committee members Martin Gipson and Kenneth Beauchamp for their advice and scholarly criticisms. A special thanks to Roseann Hannon, who in addition to serving as thesis advisor, offered invaluable assistance and personal encouragement during the course of this thesis.

The writer also wishes to gratefully acknowledge the assistance of Kathy Lowe for her help in the preparation of the stimulus materials used in this study.

Finally a very special thanks to my spouse, Chris, whose support was the greatest of all.

Abstract

Current research has suggested that musical stimuli are processed in the right hemisphere except in musicians, in whom there is an increased involvement of the left hemisphere. The present study hypothesized that the more musical training persons receive, the more they will rely on an analytic/left hemispheric processing strategy. The subjects were 10 faculty and 10 student nonmusicians, and 10 faculty and 10 student musicians. All subjects listened to a series of melodies (some recurring and some not) and excerpts (some real and some fake) in one ear and to a different series of melodies in the other ear. The task was to identify recurring vs. nonrecurring melodies and real vs. fake excerpts. For student musicians, there was a left ear/right hemispheric advantage for melody recognition, while for student nonmusicians, the situation was the reverse. Neither faculty group showed any ear preference. There were no significant differences for excerpt recognition. Two plausible explanations of the faculty performance were discussed in terms of a maturation factor and a functionally more integrated hemispheric approach to the task.

Hemispheric Asymmetries in Faculty and Student Musicians and Nonmusicians During Melody Recognition Tasks

In most living organisms, the nervous system is essentially symmetrical. One of the most outstanding features of a vertebrate's nervous system is that there are "two brains" that each control a separate half of the body. Dimond (1972) argues that the double brain evolved so that control and feedback of sensory and motor functions on one side of the body are not confused with control and feedback of sensory and motor functions on the other side of the body. He maintains that it would not make evolutionary sense for one central brain to evolve for control of a bilaterally symmetrical body.

In the phylogenetic development of the brain, there is a progressive advance in the size, complexity, and speed of "cross-talk" over the commissural fibers between the two hemispheres (Dimond, 1972). Nevertheless, even in human beings, the basic control of each half of the body from the opposite hemisphere remains. A curious evolutionary development in human's brains is the presence of a large amount of asymmetrical specialization for organization, as well as bodily function within each hemisphere. Teuber (1974) argues that brain asymmetry is related to a greater cognitive capacity, while Levy (1969) suggests that hemispheric asymmetry (or cerebral specialization) evolved to allow each hemisphere greater competence for its particular abilities. According to her, two asymmetrical hemispheres are able to achieve greater specialization than if the two hemispheres were symmetrical in function.

According to Boring (1959), the concept of hemispheric specialization for certain functions was introduced in 1861 with Broca's discovery of a language center residing in the left cerebral hemisphere. Current research has almost unequivocally demonstrated that there is a high degree of asymmetry wherein each hemisphere specializes in the type of information processed. The asymmetrical contribution of each hemisphere has been extensively documented elsewhere (see Dimond, 1972; Lezak, 1976; Ornstein, 1972).

Clinical studies demonstrating hemispheric asymmetry

A variety of studies using patients with brain damage, hemispherectomies, and mid-brain commissures (split-brain syndrome) have enriched the understanding of each hemisphere's functions, as well as brain functioning in general. Split-brain studies have been the most dramatic in demonstrating brain asymmetry because they have made it possible to measure the performance of each hemisphere, in the same individual, functioning independently on the same task. Split-brain surgery has been used in severe epileptics where severing the corpus callosum (generally the posterior 2/3's) has been found to control seizures. This operation eliminates direct cross communication between the two hemispheres, but does leave the two hemispheres otherwise unaltered. Using special techniques, it is then possible to observe each hemisphere's independent functioning without the contamination of cross-talk between the hemispheres. This work has shown that in split-brain patients, the left hemisphere deals primarily with linguistic, logical, sequential, and analytical functions, while the right hemipshere deals with direct perceptual, gestalt, pictorial, and spatial abilities (Levy, Trevarthen, & Sperry, 1972; Sperry, 1968; Sperry, Gazzaniga, & Bogen, 1969).

This distinction in abilities implies that the way in which information is processed in each hemipshere is radically different (Bogen, 1974). It has led many persons to infer that asymmetrical differences in brain functioning can be linked with the long standing duality of thought (i.e., analytic Western thought vs. nonverbal intuitive trends) in humans (Bogen, 1969; 1974; Levy-Agresti & Sperry, 1968; Ornstein, 1972; Paredes & Hepburn, 1976). The major problem with this kind of an inference is that it is almost exclusively based on speculations about patients with pathological brains, whether they be lesioned or commissurotomized.

<u>The normal brain's asymmetrical functioning</u>

There is, however, a large body of research on asymmetrical functioning in normal intact brains. Test paradigms have been designed so that, without medical intervention or cerebral injury, information concerning the asymmetrical functioning of the normal brain can be collected. Such information indicates that the normal brain does, in fact, function in terms of lateralized specialization.

<u>Traditional notions of hemispheric functioning</u>. In studying

normal brains, Broadbent (1954) was one of the first to use a technique in which, over stereo headphones, the two ears received simultaneous but different series of digits (dichotic competition). When the subjects were allowed to report digits they heard in any order, they tended to report digits presented to one ear prior to digits presented to the other ear. Exploring this phenomena further, Broadbent and Gregory (1964) found a right-ear superiority over the left for the recall of speech materials. Kimura (1973) has provided a review of all the various functions that have been assessed using derivations of this basic technique. She reported that the right ear (left hemisphere) is superior in the recognition of words and syllables, while the left ear (right hemisphere) shows a superiority in melodic patterns and nonspeech sounds. This includes recognition, reaction time, and most particularly, memory (Goodglass & Peck, 1972; Hardyck, Tzeng, & Wang, 1978; Oscar-Berman, Goodglass, & Donenfeld, 1974). Kimura (1973) further points out that asymmetry extends into visual and manual areas as well. She reports that the right visual field (left hemisphere) can better deal with words and letters while the left visual field deals best with spatial and geometric forms. In manual areas, hand gestures and articulated hand movements during speech tend to opposite the dominant hemisphere whether the dominant hemisphere is on the left or right side.

<u>Evidence contrary to traditional views</u>. While asymmetrical

function has been demonstrated in normal brains, there are some inconsistancies in the data of current studies. For example, Kiersch and Megibow (Note 1) showed two modes of pictorial stimuli to college subjects. When line drawings and photographs were shown to the subjects' right visual fields (left hemispheres), they could readily process line drawings, but not photographs. This is contrary to the standing belief that the right hemisphere deals exclusively with pictorial stimuli while the left does not.

Similarly, word recognition has been considered a clearly left hemispheric mediated function, particularly in light of split-brain research. However, Pirozzolo and Rayner (1977) have recently demonstrated that in physiologically normal subjects, word recognition is actually a multistage process utilizing both hemispheres. They have argued that feature analysis is done by the right hemisphere, while decoding and naming is carried on by the left hemisphere.

In another study, Shankweiler and Studder-Kennedy (1967) reported that in dichotic competition, the right ear (left hemisphere) showed a preference for consonants rather than vowels. This would not be expected if language is processed totally in the left hemisphere. The authors attributed this unexpected finding to the differing linguistic roles of consonants and vowels in speech. They argue that consonants are more important in coding the semantic aspects of language than are vowels. Supporting this finding Simernitshaya (1974) described an unusual writing defect in a patient with a right temporal lesion. This patient tended to omit vowels but not consonants in his writing. Again, these results are contrary to the clear dichotomies found in split-brain studies that locate certain specific functions, such as language, entirely in a particular hemisphere.

Subject variable

To understand some of the inconsistancies in asymmetrical data, the subject variable is of particular interest. The preexisting cognitive repertoire that the subject brings into the experimental testing situation represents a largely unexplored and potentially profitable area for research. It may be that it is not the type of stimulus, per se, that determines hemispheric dominance during a particular task. Rather, it may be how the individual has been trained to deal with the particular stimulus that determines hemispheric mediation during the task. If the person has been trained, for example, to process musical stimuli in an analytic or sequential fashion, then left hemipsheric mediation may be important. In contrast, if the person has no training (i.e., no analytic interest) the components of the music are no longer important. Instead, the overall contour becomes important. In this case, the right hemisphere would tend to mediate.

Investigations using subjects' experience with musical stimuli as a variable support this contention. Nicherson and Freeman (1974) found that when a tone sequence was played at a fast speed, experienced listeners would analyze the sequence as a whole or overall pattern. Yet, when the sequence was played at a slower speed the same subjects would analyze the sequence using more of a spectral analysis strategy. This is a curious finding because melody has long been considered a classic gestalt demonstration where the overall contour or pattern has been assumed to be more important than the components.

Developing a specific cognitive style. Doktor and Bloom (1977) performed an EEG frequency analysis of a large corporation's presidents vs. operations researchers. They found significant cognitive differences between how the researchers and presidents approached the same analytic puzzles. Because of EEG desynchronization in the left hemisphere (believed to indicate left hemispheric activity) during the analytic puzzles in the researchers and not the presidents, it was implied that the researchers had developed an analytic cognitive style. Along the same lines, Doktor (1970) tested a group of engineering freshmen. Approximately four years later, after half the group had left the engineering program in favor of other majors, the same subjects were retested. Where no differences existed between groups on symbolic vs. iconic abilities as freshman, as seniors, engineers favored a symbolic over iconic cognitive style. He argued that the training in the engineering program resulted in the development of a specific kind of problem solving strategy. It can be speculated that this was also a change in hemispheric mediation for certain tasks.

Van Lancker and Fromkin (1973) have shown that how an individual is trained to treat a certain class of stimuli does seem to be an important variable in determining hemispheric mediation. When, for example, a typical right hemispheric function such as pitch discrimination is used in linguistic processing (as in the Thais language), then pitch discrimination becomes lateralized in the left hemisphere.

Hemispheric differences: Not what but how information is processed. In explaining the relevance of the subject variable in hemispheric mediation of certain stimuli, recent authors (Bever & Chiarello, 1974; Gates & Bradshaw, 1977; Goldberg, Vaughan, & Gerstman, 1978) have argued that each hemisphere functions as a descriptive system for handling certain classes of material. Hemispheric functioning is explained in terms of a mode of working. This position does not conflict with cortical-anatomical research findings which link the left hemisphere with, for example, analytic abilities and the right hemisphere with gestalt perception. It does conflict with generalizations that imply that certain functions are located in a particular hemisphere and cannot change.

Describing hemispheric functioning in terms of different ways of handling information, rather than in terms of the type of information handled, allows for a more adequate description of each hemisphere's role in the normal brain and accounts for more research data. In this way, each hemisphere is no longer tied to certain classes of stimuli (i.e., right hemisphere to music), but rather is related to how the particular stimulus is handled by the subject.

Specialized processing strategies. The idea of descriptive processing systems, rather than specific locations of cognitive function, is important when dealing with some contradictory findings. The importance of the subject as a key variable lies in the fact that different subjects will deal with the same class of stimuli in totally different ways. For example, Bever and Chiarello (1974) have found that musically naive subjects tend to treat melodies as an unanalyzable whole and focus instead on the overall musical contour or pattern. Experienced musicians, however, treat a melody as an articulated set of relationships. It is not surprising that they found a right ear (left hemisphere) superiority for musicians and a left ear (right hemisphere) superiority for naive listeners for melody recognition.

Gordon (1975), in a reanalysis of some previous data (Gordon, 1970), correlated overall performance on a melody recognition task with ear preferences (left-right). He found that those musicians with lower overall scores tended to have higher left ear (right hemisphere) scores while those with higher scores tended to have higher right ear (left hemisphere) scores. However, the conclusion that musical sophistication draws progressively on left hemispheric functioning is premature. The level of musical experience of these subjects was not controlled and the range of musical experience was very limited. The subjects were college musicians of intermediate musical sophistication (Bever & Chiarello, 1974).

Thus, by manipulation of the subject variable through the selection of subjects with varied prior musical experience, different kinds of processing strategies should be found. The current study improves upon previous hemispheric asymmetry studies by using a much wider sampling of musical sophistication among musicians and an overall wider age range among subjects. It was hypothesized that when musicians listened to melodic sequences and excerpts, they would be more accurate in the recognition of these sequences with the right ear (left hemisphere) suggesting an analytic listening strategy. It was further expected that increasing musical experience would correlate with an increasing reliance on the right ear. When nonmusicians listened to the same melodies and excerpts, it was expected that they would favor the more traditional left ear (right hemisphere).

Method

Subjects

The subjects were 10 faculty and 10 student musicians recruited from the Conservatory of Music at the University of the Pacific. Nonmusicians included 10 faculty and 10 students recruited by making personal contacts in offices and classrooms of nonmusic departments. Prospective subjects were told the following:

> The human brain is made up of two hemispheres that appear to process information in entirely different ways. It seems that

different kinds of experiences and training can develop one of these cognitive styles over the other. I am conducting an experiment that will examine these different information processing strategies and how they are related to the specialized training that is given in certain college programs.

The experiment will consist of a series of auditory tasks and will be about 40 mins. long. The tasks are not a test of ability or achievement and will be interesting to take. Times are available throughout the day and will be arranged for your convenience.

Those expressing an interest in being subjects were asked about handedness and musical experience. Initial screening required all volunteers to be right-handed. Musician volunteers were required to be majoring-in or teaching music. Nonmusician volunteers were requested to have had "little or no musical training".

<u>Formal screening of volunteers</u>. After arrival at the laboratory, volunteers were carefully screened on several points. First, a lateral dominance test (Reitan, 1974, p. 99) was performed and only those scoring 80% and above for right handedness were used. Right handedness is an indicator that the dominant hemisphere is on the left side. This is true for 98-99% of all left-handers (Lezak, 1976, pp. 162-163). Second, volunteers were screened to ensure that all musicians had had at least 3 years of musical training in the past 5 years and that nonmusicians had less than 1 year

of musical training in the past 5 years. A self-report questionnaire was used to specify the extent of each subject's musical experience and training (Appendix 1). Subjects range from no musical experience to performing artists with over 40 years teaching experience.

Apparatus

A modified form of the procedure used by Bever and Chiarello (1974) was employed. The auditory stimuli consisted of 70 melodic sequences ranging in length from 12-18 notes. The melodies were randomly chosen from an ear-training music book which consisted of melodies of 12-18 note phrases (Alchin, 1919). Side A of the auditory tape contained 35 melodies and side B contained the other 35 melodies. Of the 35 melodies used on each side of the tape, 7 randomly selected melodies were exact replicas of melodies occurring earlier on that side. Therefore, there were 28 original melodies and 7 recurring melodies on each side of the tape. Recurring melodies always occured again on the tape as the first, second, or third melody following the original. The designation was made randomly for each recurring melody. Three secs. after every melody there was a 4 note excerpt. Twenty-eight of the excerpts were randomly chosen from previous melodies that had not been used anywhere before on the tape. Seven real excerpts were randomly chosen from previous melodies on the tape. There was a 5 sec. pause between each melody-excerpt sequence.

To allow for precise specification of the auditory stimuli, timbre, rhythm, and volume were held constant for all melodies and excerpts. A Schlicker pipe organ was used to hold timbre and volume constant. A visual metronome was used to hold rhythm constant. The metronome was timed so that a light was on for .6 sec. and off for .6 sec.. An experienced pianist played notes for the duration of the time the light was on and paused for the duration of the time the light was off. Recording speed of the tape was set at 3 3/4 in. per sec.. The final tape was played a 7 7/8 in. per sec. so that any errors in the duration of the notes or pauses were cut in half. Notes on the final tape occurred at the rate of 96 notes per min. and were in the middle C range.

Procedure

Each subject was alloted 1 hr. for testing. The author carried out the testing. After the subject arrived, the lateral dominance screening test was given, followed by taped instructions for the auditory test. These instructions were as follows:

> This is the auditory test. You will hear a series of 35 melodies and excerpts that will be played to one ear and then, there will be a 5 min. rest. After the rest, you will hear another series of 35 melodies and excerpts in the other ear. The series that you will hear will be melody, excerpt, melody, excerpt, melody, excerpt and so on. Some of the melodies that you will hear will recur again and others will occur only the one time. Immediately after each melody, whether it is a recurring melody or not,

there will be a four note excerpt. Some of these excerpts will be real and some will be fake. Your task will be first to indicate if you have heard the melody before and second to indicate if the excerpt was from the previous melody or not. On your answer sheet, circle "yes" if you have heard the melody before and circle "no" if you have not. Circle "real" if the excerpt is from the previous melody and "fake" if it is not. This test requires a large amount of concentration so listen carefully. Are there any questions?

All subjects listened to side A of the tape first in one ear and then to side B in the other ear. For each group, the order of ear presentation was counterbalanced. Responses for the auditory test were recorded by the subjects on an answer sheet that was provided (Appendix 2). During the rest period, subjects filled out the musical experience questionnaire (Appendix 1). After the experiment, subjects were debriefed and questions, if any, were answered. Debriefing was as follows:

The left hemisphere has been shown to specialize in linguistic and analytic or serial processing of information. The right hemisphere on the other hand deals with the overall pattern or gestalt.

There have been several studies that have shown that after left hemispheric damage, language is lost, but not musical abilities. For example, some persons with left hemispheric damage cannot speak, but can sing. Some have argued that musical abilities must then be located in the right hemisphere. The problem, however, is that most college programs tend to produce musicians that treat their mediums in a highly analytic fashion.

This study has hypothesized that it is not the function (i.e., music) that dictates hemispheric mediation, but rather it is the individual's way in which he deals with the medium that determines which hemisphere will play the dominant role. For example, to the musician, a melody represents an articulated set of relationships that he has learned to analyze and manipulate. Thus, the analytic left hemisphere is more important. For the nonmusician, the melody is treated as an overall pattern of sound where the components are not important. The right hemisphere, therefore, becomes important in processing this information.

In this experiment, I presented melodies to only one ear at a time. A majority of the neural pathways from one ear go to the opposite hemisphere. By presenting melodies separately to both hemispheres, I can see which hemisphere is more successful in working with the melodies. I have hypothesized that those with no musical training will rely on their right hemisphere. Conversely, I expect that the more musical training a persons have the more they will rely on their left hemispheres.

<u>Scoring the musical experience questionnaire</u>. The musical experience questionnaire was scored by giving subjects more points for

higher levels of musical achievement. If the subject circled letter "A" this was scored as 4 points. The letter "B" was scored as 3 points, "C" as 2 points and so on.

Results

The raw data for both the melody and excerpt recognition tasks were scored as the number of correct responses for each ear. The scores for each subject on each task were obtained by adding the number of correct responses for each ear together. A raw score of 70 was a perfect score. Ratio scores expressing ear preference for each task were obtained for each subject by dividing the number of correct responses of the right ear by the left ear. A number greater than one on the ratio score indicates a right ear preference, while a fractional number indicates a left ear preference.

For melody recognition, there were distinct differences between groups in raw scores (see Figure 1). A completely randomized factorial two-way ANOVA was performed on these scores. Musical experience (musician - nonmusician) and educational status (faculty - student) were the two factors. A significant main effect was found for musical experience, $\underline{F}\ (1, 36) = 23.2$, $\underline{p} < .05$, but not educational status. The interaction was not significant, $\alpha = .05$. Faculty musicians scored the highest ($\overline{X} = 60.1$, $\underline{S} = 2.9$) with 86% correct, followed by student musicians ($\overline{X} = 54.9$, $\underline{S} = 3.9$) with 78% correct. The faculty and student nonmusicians performed essentially the same with scores falling well below both musician groups ($\overline{X} = 50.2$, $\underline{S} = 5.2$; $\overline{X} = 49$, S = 7.3) with 72% and 70% correct respectively.

A completely randomized factorial two-way ANOVA was performed on the melody recognition ratio scores expressing ear preference. Musical experience and educational status were the two factors. A significant main effect was found for musical experience, F (1,36) = 4.3, $p < .05$. An analysis of the simple main effects of the interaction found the means of the student musicians and student nonmusicians to differ significantly, F (1,19) = 11.8, $p < .05$, while those of the faculty musicians did not. Of the 10 student musicians, seven scored in the direction hypothesized, while three did not. All the student nonmusicians scored in the direction hypothesized. There were no significant differences between the student and faculty musicians or the student and faculty nonmusicians. The mean ratios for each group were: Faculty musicians, $\overline{X}$ = .99, S = .08; student musicians, $\overline{X}$ = 1.06, S = .14; faculty nonmusicians, $\overline{X}$ = 1.0, S = .16; student nonmusicians, $\overline{X}$ = .90, S = .06 (see Figure 2).

A Pearson product moment correlation coefficient was used to determine the magnitude of the correlation between the scores on the musical experience questionnaire and the ratio scores expressing ear preference for the melody recognition task for musicians only. The scores ranged from a strong right ear preference in some of the lesser experienced music students, to no consistant ear preference in the highly experienced music faculty (see Figure 3). A significant r (18) of -0.60, $p < .05$ was obtained indicating that, given a

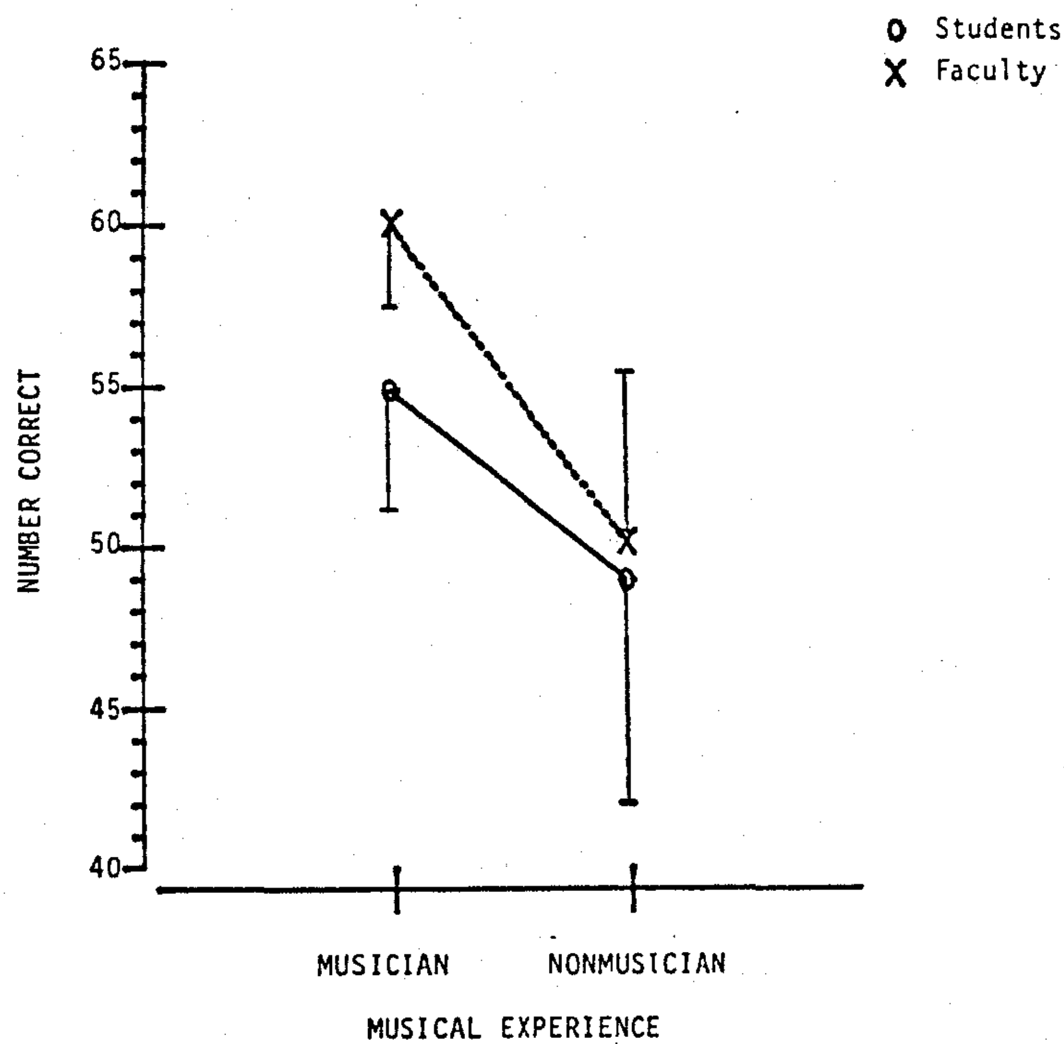

Figure 1. Mean raw scores for student and faculty musicians and nonmusicians on the melody recognition task.

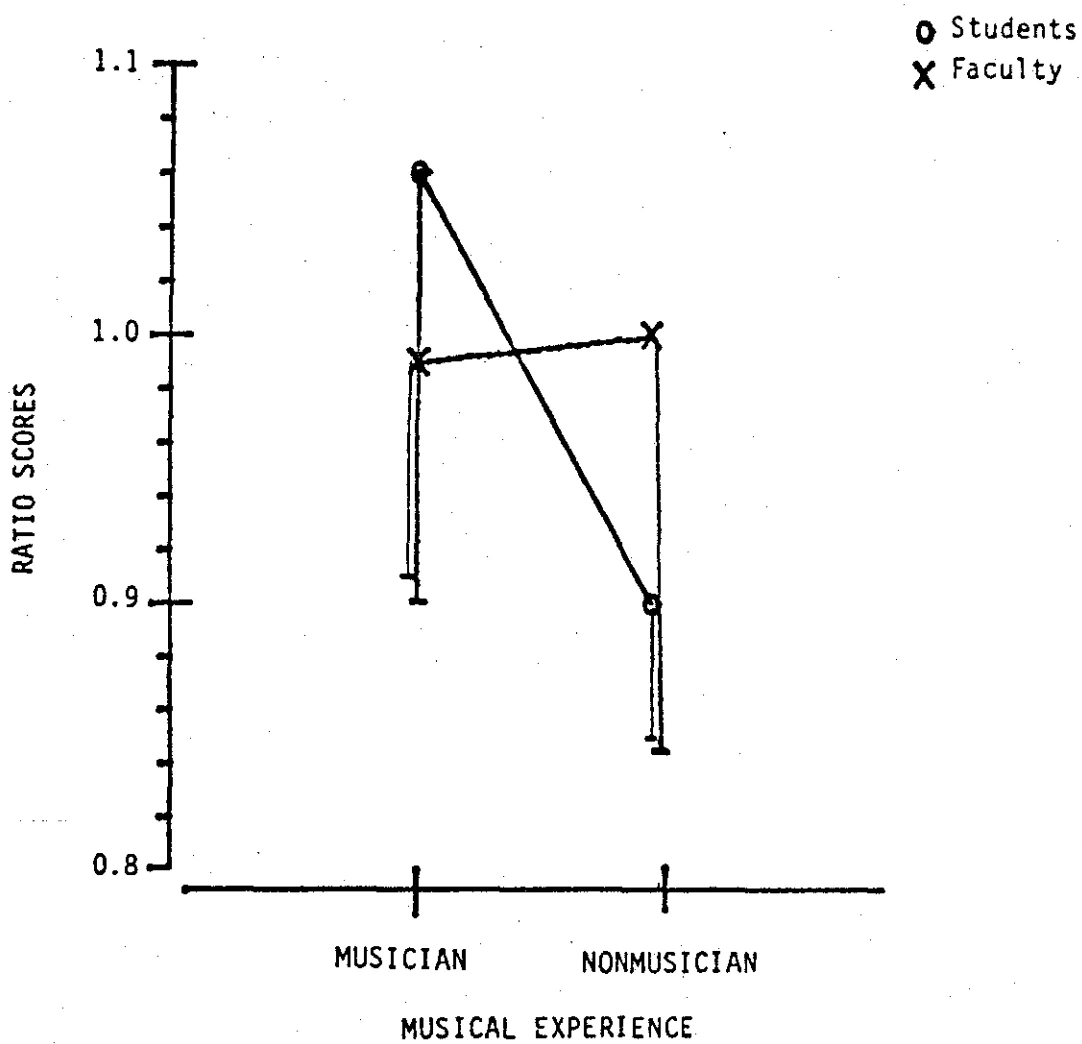

Figure 2. Mean ratio scores of ear preference for student and faculty musicians and nonmusicians on the melody recognition task.

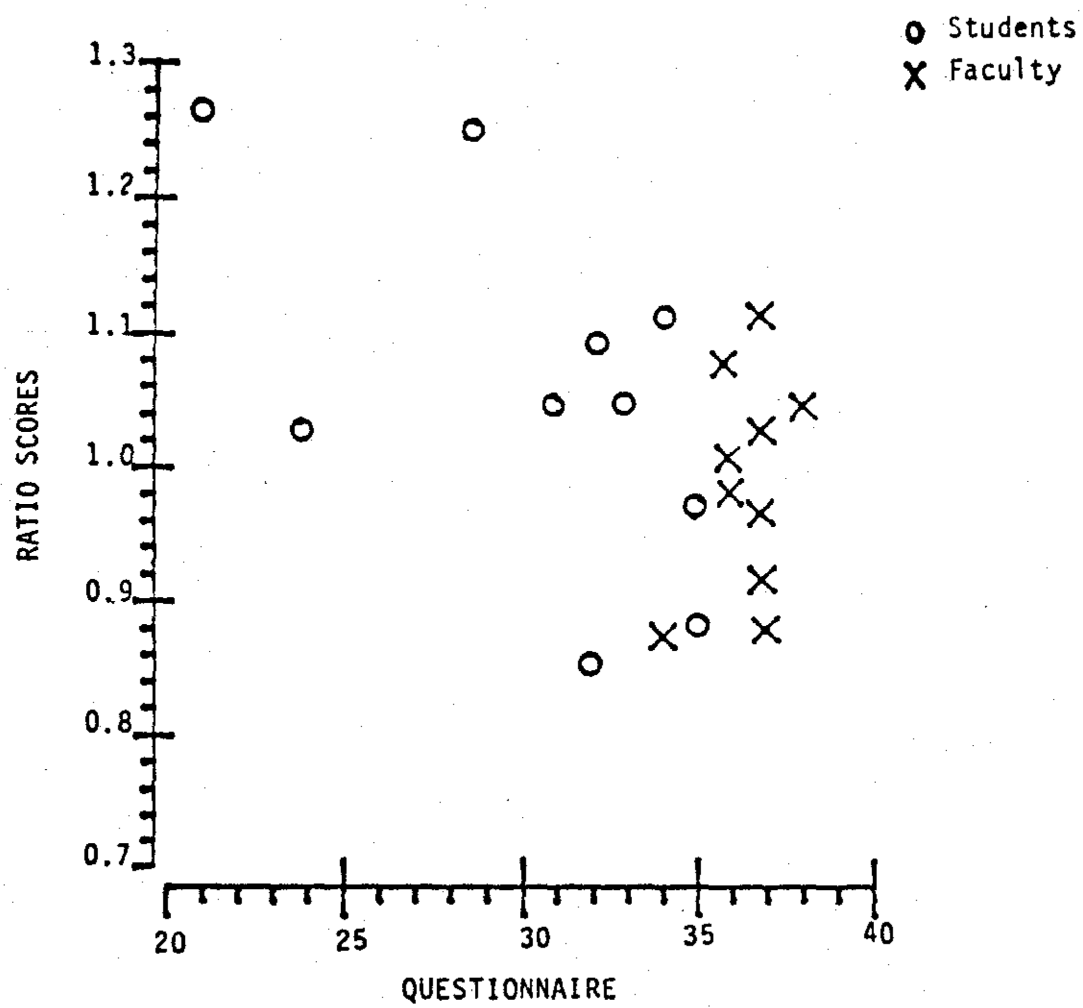

Figure 3. Scatter plot of scores on the musical experience questionnaire and the ratio scores expressing ear preference for the melody recognition task for student and faculty musicians.

musically experienced group, increased musical experience tends to correlate with a balanced rather than a strong right ear preference for melody recognition.

For excerpt recognition, there was substantial overlap between groups in raw scores. Student musicians scored the highest ($\overline{X}$ = 52.7, $\underline{S}$ = 3.4) with 75% correct, followed by faculty musicians ($\overline{X}$ = 49.7, $\underline{S}$ = 7.3) with 71% correct, faculty nonmusicians ($\overline{X}$ = 47, $\underline{S}$ = 3.8) with 67% correct, and student nonmusicians ($\overline{X}$ = 45.5, S = 4.2) with 65% correct (see Figure 4). A completely randomized factorial two-way ANOVA was performed on these scores. Musicial experience and educational status were the two factors. A significant main effect was found for musical experience $\underline{F}$ (1,36) = 10.1, $\underline{p} < .05$, but not for educational status. The interaction was not significant (see Figure 4).

A completely randomized factorial two-way ANOVA was performed on the excerpt recognition ratio scores. There were no significant effects, α = .05. The mean ratios for each group were: Faculty musicians, $\overline{X}$ = .98, $\underline{S}$ = .18; student musicians, $\overline{X}$ = .96, $\underline{S}$ = .11; faculty nonmusicians, $\overline{X}$ = .98, $\underline{S}$ = .12; student nonmusicians, $\overline{X}$ = 1.1, $\underline{S}$ = .17 (see Figure 5).

The Pearson product moment correlation coefficient between musical experience and ratio scores for the excerpt recognition was negative, $\underline{r}$ (18) = -0.22, but failed to reach significance, α = .05 (see Figure 6).

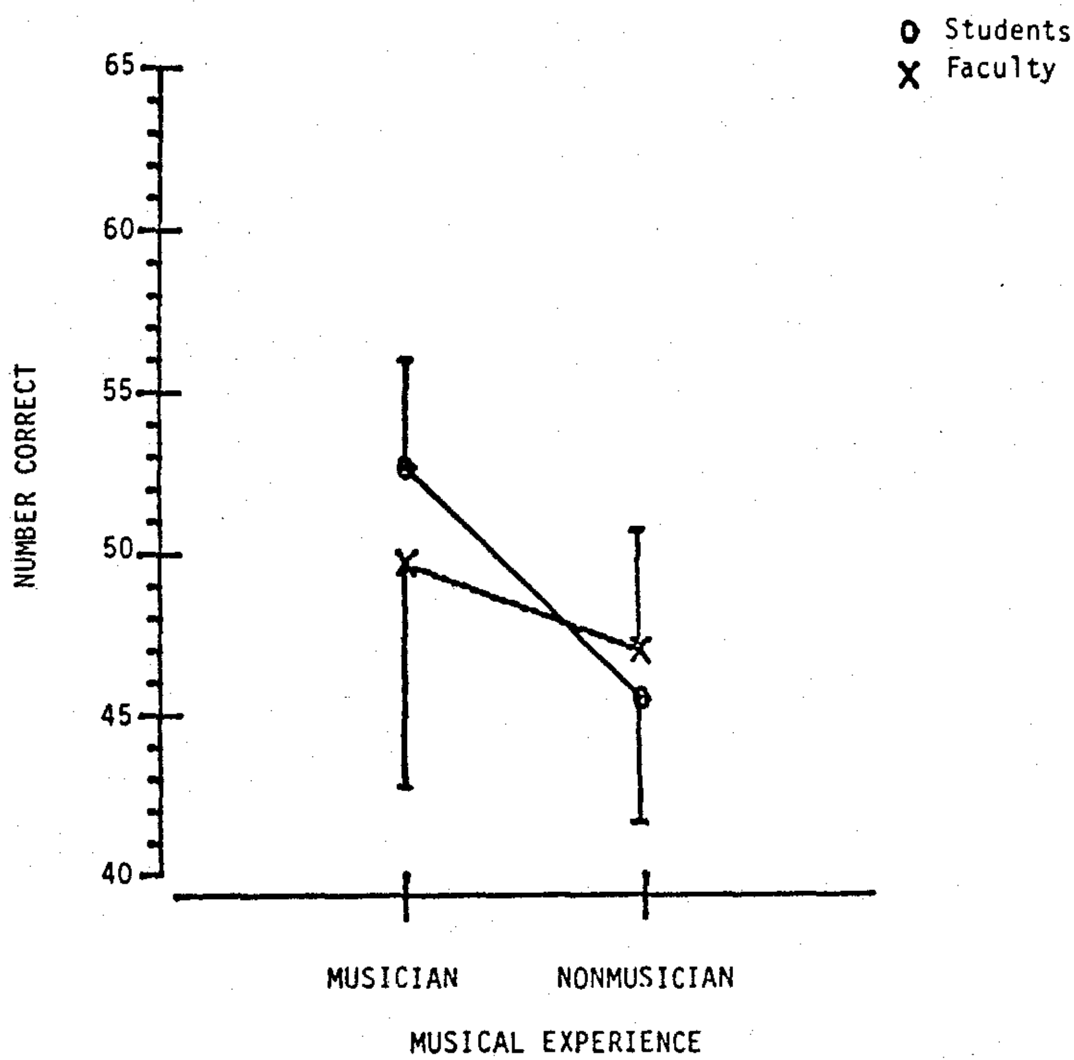

Figure 4. Mean raw scores of ear preference for student and faculty musicians and nonmusicians on the excerpt recognition task.

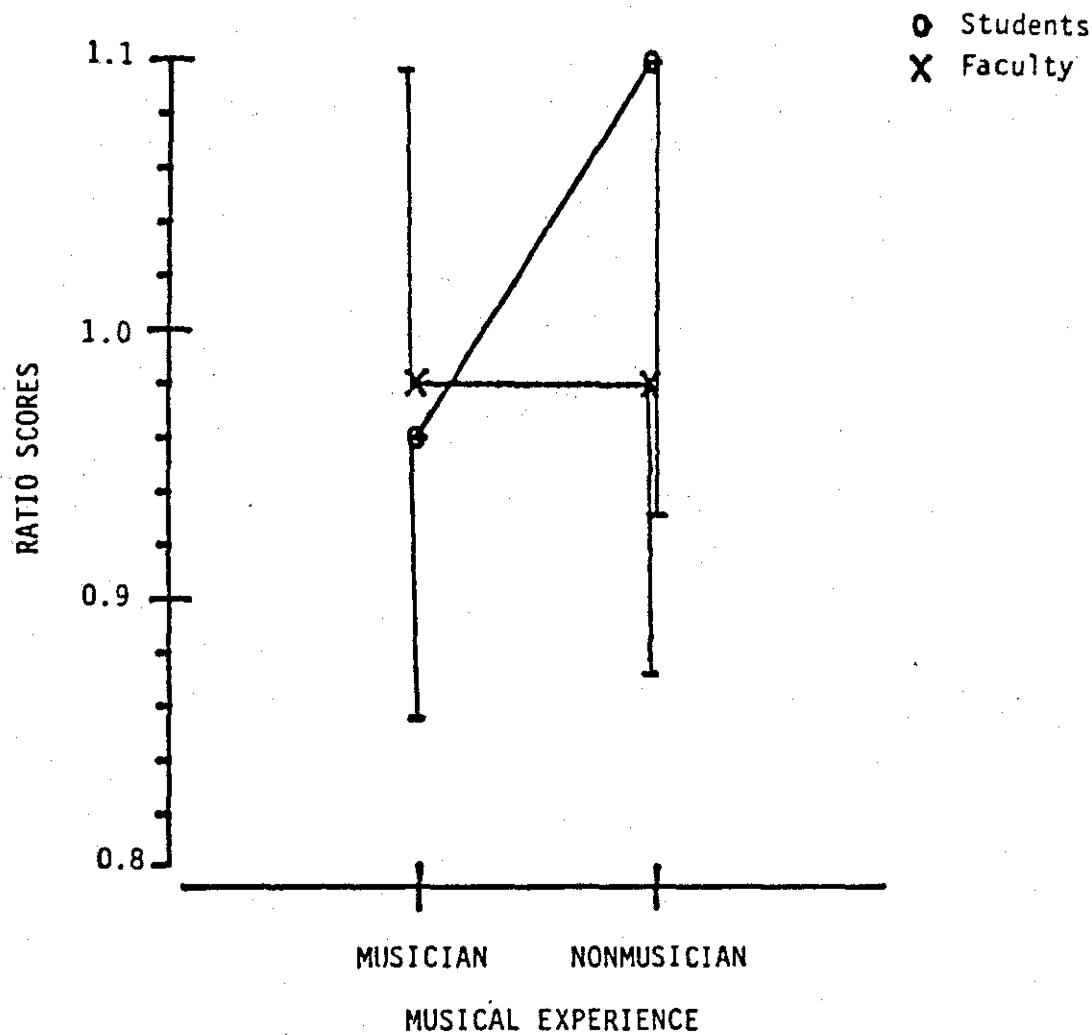

Figure 5. Mean ratio scores of ear preference for student and faculty musicians and nonmusicians on the excerpt recognition task.

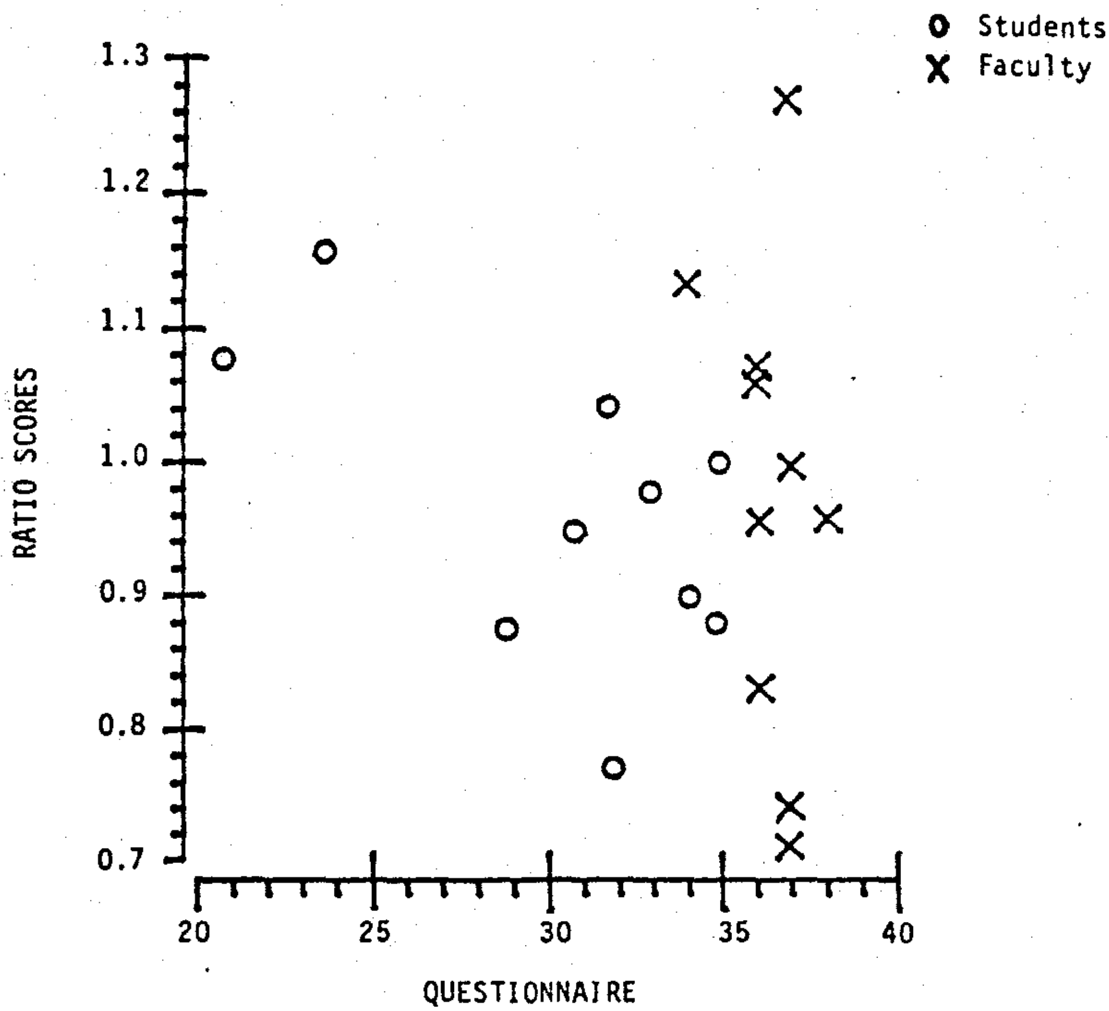

Figure 6. Scatter plot of scores on the musical experience questionnaire and the ratio scores expressing ear preference for the excerpt recognition task for student and faculty musicians.

Discussion

In accord with other studies (Bever & Chiarello, 1974; Johnson, Bowers, Gamble, Lyons, Presbrey, & Vetter, 1977; Gordon, 1975), student musicians scored better with their right ears (left hemispheres) and student nonmusicians scored better with their left ears (right hemispheres) for melody recognition. However, neither the faculty musicians nor faculty nonmusicians showed a consistant ear preference. The lack of an ear preference in the faculty musicians is contradictory to speculations made by Bever and Chiarello (1974) and Gordon (1975) that there is an increased reliance among experienced musicians on the right ear (left hemisphere). In fact, in the present study, the correlation of musical experience and ear preference among musicians showed that increased musical experience tended to correlate with a decreasing tendency to favor the right ear (left hemisphere) for melody recognition.

For the excerpt recognition task, there were no significant differences for ear preference. Bever and Chiarello (1974), who used a two note excerpt instead of the present four note excerpt, did not find a significant right ear superiority among experienced listeners for excerpt recognition either. They cautioned that the excerpt recognition task may have been too difficult or insensitive as a response measure.

In the present experiment, many subjects remarked afterwards that they had trouble concentrating on the excerpts because they were concentrating on remembering the melodies. Indeed, the results of the mean excerpt recognition score for each group was lower when compared to that group's mean melody recognition score.

The consistent ear preference in the melody recognition task for the student musicians and nonmusicians suggests that there is an underlying differential hemispheric involvement between the groups for the same task (Rosenzweig, 1951). For the student musicians, it can be inferred that when their melody recognition strategy emphasizes the components or the sequential aspects of the melody the left hemisphere will be more successful. Conversely, for the student nonmusicians, when their strategy focuses on the overall contour of the sound of the melody, the right hemisphere will be more successful. It would seem that strategies learned in musical training will produce a neurological shift in hemispheric preference for melody recognition.

While the student data for the melody recognition task supported the original hypothesis, the data from the faculty musicians and faculty nonmusicians did not. In both faculty groups, there was no consistent ear preference. However, the melody recognition task was a sensitive response measure in that it clearly discriminated overall musical ability in each group (scores regardless of ear preference). Faculty musicians scored the highest followed by student musicians and then the two nonmusician groups. Because the melody recognition task discriminated overall musical ability, it would appear that the measure was sensitive to the lack of hemispheric differences in the faculty groups. These results, therefore, are worth further consideration.

One of the more obvious differences between the faculty groups and the student groups is age. Little is known about what neurological developments take place after the major period of development (adolescence). This is particularly true in the normal functioning brain where most asymmetry research has concentrated on the college student populations. Physical maturation is an open question and has not been systematically explored as a variable affecting hemispheric research.

It may be that education and/or experience produce a functionally more sophisticated brain that utilizes both rather than just one hemisphere for information processing. Davis and Schmit (1971), Dimond (1971), and Dimond (1972) have shown that when information is processed simultaneously in both hemispheres, the speed and accuracy of responses are increased. This suggests that duplication of operations increases the probability of detecting and identifying a signal.

The results of the two student groups support the concept that there are two processing systems for the same function. In addition, the results of the faculty groups indicate that there is no inherent advantage to relying consistantly on a left or right hemispheric strategy for melody recognition. The fact that the music faculty was the highest scoring group and showed no ear preference argues for simultaneous rather than independent processing of information by the two hemispheres as the most efficient mode of information processing.

Thus, education and/or general experience may develop a functionally more sophisticated brain that utilizes both information channels, rather than relying on a single channel (hemisphere) for information processing.

Several possible directions for future hemispheric research are suggested by this experiement. Studies with "split-brain" and brain lesioned patients have demonstrated distinct differences between the two hemispheres. Research based on small statistical differences with normal subjects have emphasized these differences at the expense of the concept of hemispheric integration. It may be profitable to explore the concept of interhemispehric communication instead of the concept of hemispheric asymmetry, since hemispheric integration may be a more characteristic mode of normal brain functioning.

Similarly, much of the research with normal subjects on hemispheric asymmetry has involved college subjects. Variables such as age, education, and individual strategies have been largely unexplored. Manipulation of the subject variable provides a means to investigate the role of hemispehric function in different groups.

Reference Note

1. Kiersch, M. & Megibow, M. Hemispheric asymmetry in the recognition of tachistoscopically presented photographs and line drawings. Paper presented at the meeting of the Western Psychological Association, San Francisco, April, 1978.

Alchin, C. Tone thinking and ear testing. Los Angeles: C. Alchin, 1919.

Bever, T. & Chiarello, R. Cerebral dominance in musicians and non-musicians. Science, 1974, 185, 537-539.

Bogen, J. Implications for psychiatry of left and right cerebral specialization. Archives of General Psychiatry, 1974, 31, 257-259.

Bogen, J. The other side of the brain II: Appositional mind. Bulletin of the Los Angeles Neurological Society, 1969, 34, 135-162.

Boring, E. A history of experimental psychology. New York: Appleton Century Crofts, 1957.

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

Broadbent, D. The role of auditory localization in attention and memory span. Quarterly Journal of Experimental Psychology, 1954, 47, 191-196.

Davis, R., & Schmit, V. Timing and transfer of information between hemispheres in man. Acta Psychologica, 1917, 35, 335-346.

Dimond, S. The double brain. Baltimore: Williams & Wildins Co., 1972

Dimond, S. Use of two cerebral hemispheres to increase brain capacity. Nature, 1971, 232, 270-271.

Doktor, R. The development and mapping of certain cognitive styles of problem solving. Dissertation Abstracts International, 1970, 31, 1432.

Doktor, R., & Bloom, D. Selective lateralization of cognitive style related to occupation as determined by EEG alpha asymmetry. Psychophysiology, 1977, 14, 385-387.

Gates, A., & Bradshaw, J. The role of the cerebral hemispheres in music. Brain, 1977, 4, 403-431.

Goldberg, E., Baughan, H., & Gerstman, L. Nonverbal descriptive systems and hemispehric asymmetry: Shape vs. texture discrimination. Brain and Language, 1978, 5, 249-257.

Goodglass, H., & Peck, E. Dichotic ear order effects in Korsakoff and normal subjects. Neuropsychologia, 1972, 10, 211-217.

Gordon, H. Hemispheric asymmetries in the perception of musical chords. Cortex, 1970, 6, 387-398.

Gordon, H. Hemispheric asymmetry and musical performance. Science, 1975, 189, 68-69.

Hardych, C., Tzeng, O., & Wang, W. Cerebral lateralization of function and bilingual decision processes: Is thinking lateralized? Brain and Language, 1978, 5, 56-71.

Johnson, R., Bowers, J., Gamble, M., Lyons, F., Presbrey, T., & Vetter, R. Ear superiority for tone sequences. Cortex, 1977, 13, 295-299.

Kimura, D. The asymmetry of the human brain. Scientific American, 1973, 228, 70-78.

Levy, J. Possible basis for lateral specialization of the human brain. Nature, 1969, 224, 614-615.

Levy-Agresti, J., & Sperry, R. Differential perceptual capacities in major and minor hemispheres. Proceedings of the National Academy of Sciences, 1968, 61, 1151 (Summary).

Levy, J., Trevarthan, C., & Sperry, R. Perception of bilateral chimeric figures following hemispheric deconnection. Brain, 1972, 95, 61-79.

Lezak, M. Neuropsychological Assessment. New York: Oxford Press, 1976.

Nickerson, R., & Freeman, B. Discrimination of the order of the components of the repeating tone sequences: Effects of frequency and extensive practice. Perception and Psychophysics, 1974, 16, 471-477.

Ornstein, R. The psychology of consciousness. San Francisco: W.H. Freeman & Co., 1972.

Oscar-Berman, M., Goodglass, H., & Donnenfeld. Dichotic ear-order effects with nonverbal stimuli. Cortex, 1974, 10, 270-277.

Paredes, J., Hepborn, M. The split-brain and the culture-and-cognition paradox. Current Anthropology, 1976, 17, 121-126.

Pirozzolo, F., & Rayner, K. Hemispheric specialization and word recognition. Brain and Language, 1977, 4, 248-261.

Reitan, R., & Davison, L. Clinical neuropsychology: Current status and applications. New York: John Wiley & Sons, 1974.

Rosenzweig, M. Representation of the two ears at the auditory cortex. American Journal of Physiology, 1951, 167, 147-158.

Shankweiller, D. & Studder-Kennedy, M. Identification of consonants and vowels presented to left and right ears. Quarterly Journal of Experimental Psychology, 1967, 19, 59-63.

Simernitskaya, E. On two forms of writing defects following brain lesions. In S. Dimond & J. Beaumont (Eds.) Hemisphere functions in the human brain. New York: Halstead Press, 1974

Sperry, R. Mental unity following surgical disconnection of the cerebral hemispheres. The Harvey Lectures, Series 62, New York: Academic Press, 1968. (293-323)

Sperry, R., Gazzaniga, M., & Bogen, J. Interhemispheric relationships: The neocortical commissures: Syndromes of hemispheric deconnection. In P. Vinken, & G. Bruyn (Eds.) Handbook of clinical neurology (Vol. 4). 1974.

Van Lancker, D., & Fromkin, V. Hemispheric specialization for pitch and "tone": Evidence from Thai. Journal of Phonetics, 1973, 1, 101-109.

Appendix 1

Musical Experience Questionnaire

Circle the letter that applies most to you.

1. Musical training

a.) Majored in music during college and/or have had extensive private lessons

b.) Have had more than one year of private music lessons in the past five years

c.) Have had less than one year of private music lessons in the past five years

d.) No formal musical training

2. Higher education in music

a.) Holding a graduate degree in music

b.) Currently in a graduate music program

c.) Less than four years of college training in music

d.) No higher education in music

3. Musical activity

a.) Have been paid to perform as a studio or concert artist

b.) Have been or am a professional music teacher

c.) Have appeared in amateur performaces or public recitals

d.) No public appearances

4. Role of music in daily life

a.) Teach music

b.) Practice every day

c.) Practice at least once a week

d.) No specific daily thought given to music

5. Musical ability

a.) Compose and write songs, concertos, etc. (written compositions)

b.) Can read and play sheet music

c.) Improvise or play by ear

d.) Cannot read, write, or play music

6. Can you translate a melody that you have heard on to paper?

a.) Yes

b.) All but the most complex melodies

c.) Only less complex melodies

d.) No

7. Can you sight read?

a.) Yes

b.) Sometimes have trouble

c.) Often have trouble

d.) Not at all

8. How many days a week do you practice on an average?

a.) 7 - 6

b.) 5 - 4

c.) 3 - 2

d.) 1 - 0

Appendix 2

Side A

	Have you heard this melody before?		Was this a real excerpt from the previous melody?	
1	yes	no	real	fake
2	yes	no	real	fake
3	yes	no	real	fake
4	yes	no	real	fake
5	yes	no	real	fake
6	yes	no	real	fake
7	yes	no	real	fake
8	yes	no	real	fake
9	yes	no	real	fake
10	yes	no	real	fake
11	yes	no	real	fake
12	yes	no	real	fake
13	yes	no	real	fake
14	yes	no	real	fake
15	yes	no	real	fake
16	yes	no	real	fake
17	yes	no	real	fake
18	yes	no	real	fake
19	yes	no	real	fake

20	yes	no	real	fake
21	yes	no	real	fake
22	yes	no	real	fake
23	yes	no	real	fake
24	yes	no	real	fake
25	yes	no	real	fake
26	yes	no	real	fake
27	yes	no	real	fake
28	yes	no	real	fake
29	yes	no	real	fake
30	yes	no	real	fake
31	yes	no	real	fake
32	yes	no	real	fake
33	yes	no	real	fake
34	yes	no	real	fake
35	yes	no	real	fake

Side B

	Have you heard this melody before?		Was this a real excerpt from the previous melody?	
1	yes	no	real	fake
2	yes	no	real	fake
3	yes	no	real	fake
4	yes	no	real	fake

5	yes	no	real	fake
6	yes	no	real	fake
7	yes	no	real	fake
8	yes	no	real	fake
9	yes	no	real	fake
10	yes	no	real	fake
11	yes	no	real	fake
12	yes	no	real	fake
13	yes	no	real	fake
14	yes	no	real	fake
15	yes	no	real	fake
16	yes	no	real	fake
17	yes	no	real	fake
18	yes	no	real	fake
19	yes	no	real	fake
20	yes	no	real	fake
21	yes	no	real	fake
22	yes	no	real	fake
23	yes	no	real	fake
24	yes	no	real	fake
25	yes	no	real	fake
26	yes	no	real	fake
27	yes	no	real	fake
28	yes	no	real	fake

29	yes	no	real	fake
30	yes	no	real	fake
31	yes	no	real	fake
32	yes	no	real	fake
33	yes	no	real	fake
34	yes	no	real	fake
35	yes	no	real	fake