A Musician's Guide to the Human Brain

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Article:

In recent years there has been a tremendous upsurge in the interest musicians have shown in the brain. Consider these titles as just one indication; Music and the Brain: Studies in the Neurology of Music (Critchley and Hensen, 1977); Art Education and Brain Research (Regelski, 1978); "Neurophysiology and Musical Behavior" (in Handbook of Music Psychology, Hodges, 1980); Music, Mind, and Brain: The Neuropsychology of Music (Clynes, 1982). In addition, numerous research studies on music and the brain have been published in both music and nonmusic journals.

What is the reason for all this newfound interest? Where is it leading? Is there anything in all this that would be of help to music educators in their daily activities in the classroom, rehearsal hall, and studio? The purpose of this article is to provide a general overview of the way the brain works and then to suggest some teaching strategies based on this knowledge.

Six Brief "Snapshots" of the Brain

By way of analogy, imagine that you had only six photographs with which to describe America to someone who had never been here. You might hold up each snapshot and describe some of the things it represents. In doing so, you would, of course, have to generalize and could only give a broad overview of what our country is really like. In this way, we are going to look at six "snapshots" of the brain. Each snapshot represents one way of looking at the human brain and how this viewpoint relates to music. None of the snapshots, nor all of them together can provide a complete description. However, collectively they should contain enough information to provide a general introduction to the topic.

Snapshot #1: The Brain in Numbers

Consider these numerical descriptions of the human brain:

- The adult brain weighs approximately three pounds and contains over 10 billion cells (neurons).
- Each cubic inch of brain matter contains more than 100 million cells.
- Two neurons may interconnect with each other as many as 1,000 times.
- A single cell may be connected to as many as 60,000 other cells.
- The number of interconnections between brain cells may exceed the "distance" in miles across the United States times the number of stars in the Milky Way, if not double that" (Fincher, 1976, p.31).
- Over 100 million separate coded messages reach the brain every second.
- Adults lose approximately 10,000 brain cells per day.

What an incredibly complex organ! The sheer magnitude of these numbers is overwhelming. They do not help us understand the brain so much as they create a sense of awe. As musicians, we know how complex music is; seeing how complex the brain is helps us to know that the relationship between the two is not a simple one. No easy answers to questions nor simple solutions to problems will be forthcoming from the next five snapshots. However, there are some ways to view the brain that are more likely to give us a clearer understanding.

Snapshot #2:
The Electro-Chemical Brain

Each of the 10 billion brain cells that make up the brain is a miniature electrical-chemical factory. The smell of a rose, the sound of a Mozart symphony, or any information that comes to the brain from sensory organs is translated into electrical impulses, which are made possible by complex chemical actions. For example, at the point where two neurons connect, a synapse, there is actually a tiny space which separates the two. Small though this space may be--.00002 mm wide--it is large enough to interrupt the flow of electricity. Chemical transmitters carry the message across this space.

The relationship between electrical and chemical activity can also be seen in the way memory works. Short-term memories, those lasting up to 30 seconds, are electrical. If you look up a phone number, remember it long enough to dial, then forget it, the memory was short-term. If conditions are right, short-term memories can become long-term memories. Longterm memories are chemically encoded and stored in the brain; we may have difficulty retrieving specific long-term memories, but researchers tell us that they are rarely lost and instead stay with us for life.

Researchers are beginning to make some connections between the brain's electrical and chemical properties and musical behavior. However, the information that is currently available is quite incomplete and leads perhaps to more speculation than practical application. In the next two paragraphs we will take a look at what we do know about the relationship between the brain' electrical-chemical nature and music.

The electrical activity of the brain can be measured via an EEG (electroencephalogram). The resultant brain waves give an indication of general - Lied states of arousal, such as deep sleep, periods of dreaming, relaxed awareness, and full alertness. A number of pioneering research efforts have indicated that listening to music does affect one's brain waves. However, precisely what these effects are, and what differences there may be between musicians and nonmusicians, males and females, and other similar questions, have yet to be answered.

Perhaps even less is known about the effects of music listening on brain chemistry. However, there are some preliminary indications that music listening increases the brain's output of if a group of chemicals called endorphins. Because endorphins are morphinelike chemicals, this may explain 3 number of music-related phenomena; (L) It may explain such common physical reactions to music listening as pleasurable tingling, goosebumps, or a compulsion to dance or tap the feet. (2.) It may explain why listening to music sometimes reduces one's sensitivity to pain, as with long-term cancer patients or in dentistry. (3.) It might explain music's role in helping human beings reach altered states of consciousness-this occurs in primitive ceremonies with singing, drumming, and dancing and in more "sophisticated" rituals such as rock con - certs, revival meetings, cocktail parties, discotheques, and sporting events (pep rallies, football and basketball game hysteria), Needless to say, there is much more to learn about the effects of music on brain chemistry.

Snapshot #3; The Holographic Brain

Karl Pribram (1982) has suggested that the brain works in a fashion similar i holography. Holography is a photographic technique which presents a three-dimensional image, rather than the usual two-dimensional one we see in normal photographs. Besides the three-dimensional aspect, there are some additional advantages of holograms. They can be superimposed on one another, so that a huge number of images can be stored in a small space. Furthermore, it takes only a small fragment of a hologram to reconstruct the entire image.

Pribram suggests that the brain stores memories in holographic fashion. If true, this would explain why the

brain can store so much information; a holographic model of the brain would allow for the storage of a quadrillion bits of information, enough to allow for the storage of a thousand bits of information per second for 75 years and still use only a fraction of the total capacity! It would also help to explain how the whiff of an odor, the snippet of a conversation, or a fleeting glimpse of a person can trigger the recall of a total experience.

Applying the holographic model to musical behavior might explain how musicians can remember so many different melodies. It would also explain how just a fragment of a composition-a few notes of the melody, a chord or two, a particular timbral combination --can bring back a recollection of the entire piece. Finally, it helps to explain how music, unlike paintings, must be reconstructed over time. Relationships among the beginning, middle, and end of a piece must be made in a holistic fashion, rather like a three-dimensional model.

Snapshot #4:
The Brain as Pattern Detector

As the first snapshot indicated, the brain receives a tremendous amount of information every second from the sensory organs. The brain makes sense of all this data by organizing it into meaningful patterns. As new information is received it is immediately compared to stored patterns. If the pattern is an easily recognizable one, such as the sound of your mother's voice, recognition can be almost instantaneous.

In comparing new experiences to previous ones, the brain has a tremendous advantage over that other marvelous pattern detector, the computer. While a computer requires an exact match, the brain can deal with an "almost" match; it will match the new experience up with the best possible fit (that is, with a previous experience which most closely resembles the new experience). For example, you will have no trouble filling in the missing letter correctly in the following sentences, while most computers cannot do it at all:

The little girl was crying because she was 1—st.

He was the 1—st one to arrive at the party.

She had gone to the grocery store without her 1—st.

When the brain can detect no recognizable pattern in new information it will disregard the information or it will respond affectively, perhaps with a sense of frustration, rage, or confusion.

Viewing the brain as a pattern detector has tremendous implications for music educators. First, we recognize, of course, that as musicians we are trained to recognize musical patterns. The sound of an oboe, for example, provides instant recognition and identification. Likewise, we recognize certain patterns of sound as being that of a particular composer, and even from a specific piece by that composer. If we wish our students to "understand" music, they must be trained to recognize musical patterns. Further implications will be explored in the final section.

Snapshot #5: The Triune Brain

Paul MacLean (1973) envisions the brain as being made up of three layers. The innermost layer he calls the reptilian brain. The reptilian brain is the oldest part of the brain and it is largely responsible for regulating such routine body functions as blood pressure, body temperature, and blood sugar levels. It is also concerned with the ritualistic, stereotypical aspects of our behavior. (Did you ever notice how students tend to sit in the same seats, even in a classroom where there are no assigned seats?)

The paleomammalian brain is the next oldest part of our brain and consists of what is more commonly known as the limbic system. The limbic system is involved in a number of complex processes, but for our purposes, its most important role might be that of providing us with the full range of human emotions. The newest part of the brain in our evolutionary history is the neomammalian brain, or the cerebral cortex. The cerebral cortex is that wrinkled covering of "grey matter" which controls our thinking and conscious awareness.

Of course, all three brains are integrated to form one whole and it is important to recognize that they work together—internal bodily processes continue involuntarily, while our affective and cognitive lives are inextricably intertwined, All three parts of the triune brain may have a role to play in musical behavior: The reptilian brain contributes the ritual and ceremony often associated with musical performances, such as the pomp of an opera production; the paleomammalian brain provides the feelingful aspects and the neomammalian brain allows for analytic awareness and "masterminds" the whole affair, making possible all the unique sensations of a musical experience.

Snapshot #6: The Divided Brain

In the final snapshot, the brain will be viewed as consisting of two halves: the left hemisphere of the brain for most individuals processes information primarily in a verbal, logical, analytical, sequential manner; the right hemisphere processes information primarily in a nonverbal, intuitive, Gestalt, holistic fashion. As with the triune brain concept, it is important to stress that the two halves of the brain do not operate independently; rather, they work together as a totally integrated unit.

A considerable amount of research has been conducted to determine whether one side of the brain dominates the other in certain activities. In a general, qualified sense this appears to be true. There are certain tasks which are more likely to be dealt with in a logical, sequential mariner. For example, most persons would be likely to compute a mathematics problem in a logical, sequential fashion. However, there are many variables which might change the picture--gender, handedness, preferred mode of processing, racial/cultural background (Japanese adults tend to do their verbal processing in the right hemisphere), and so on. There are those individuals who have difficulty tracking through the logic of a mathematics problem and end up guessing. Also, a person working at higher levels of mathematics, such as Einstein did, might be using as much nonverbal intuition as verbal logic.

The situation in music is much the same. That is, there appears to be a surface dichotomy between doing certain musical tasks in a verbal, analytic fashion, while others are handled more nonverbally and holistically. However, it is more likely that most musical tasks involve both verbal and nonverbal processing.

Summary

The human brain, then, is a vastly complicated organ whose innermost secrets have yet to be revealed. Scientists do know enough, however, to give us several models of how the brain functions. In one model, behavior is explained on the basis of the brain's electro-chemical activities. In another model, the brain is seen to be a giant pattern detector, making sense of the environment through relationships among patterns. In a third model, the evolutionary stages of the brain--paleomammalian, neomammalian, and cortex--are each said to be responsible for different aspects of behavior. In a fourth model, the brain is hypothesized to work according to principles of holography. Finally, the two hemispheres of the brain have been found to process information in different but complimentary ways.

Suggestions for Teaching

One of the purposes of this journal, Update, is to make applications of research to classroom situations. This is somewhat difficult with brain research for at least two reasons. (1) The first reason might be best explained by another analogy: It is important for singers to learn about the physiology of the voice and of breathing. However, singing teachers do not normally refer to the movement of specific muscles when working with students. Likewise, knowledge of the brain can be useful to teachers, but it is difficult to make a direct connection between a specific fact of neurophysiology and a prescribed teaching technique. (2) The second reason is that the amount and kind of research needed to make classroom applications of new information derived from brain research is simply not available. In short, not enough is known about how the brain functions, especially with regard to musical behaviors, to make very many secure statements on how to teach music.

These limitations notwithstanding, some suggestions for music teachers based on current understanding of how

the brain works will be presented: Most of these suggestions appear to derive from common sense and will be very familiar to experienced teachers. Yet they may be useful in that they remind us of important concepts, they reinforce things we may already be doing, and they may explain why certain procedures are or are not effective.

1. Treat each student as the unique individual he or she is.
Certainly there has been considerable emphasis on individualizing instruction in recent years. While this is often difficult for music educators who see large numbers of students in group settings, recognizing that each person has inherited a unique, enormously complex brain and the profound effect this has on behavior can heighten our awareness of the need to see each student as special.

2. Help students to recognize and identify patterns.
This statement is just as true for the organization of a year's coursework as it is for the structure of a phrase. The brain is built to deal with patterns and when students cannot see the pattern (organization, structure, scheme, form, plan, "the way things fit together"), they are more likely to become bored, confused, or frustrated.

3. Teach students to listen to music with musical expectations.
As a pattern detector, the brain functions by making predictions about future events based on past experiences. A simple musical example would he to play a major scale, stopping on the leading tone, Naturally, everyone raised in a Western culture Could safely predict the tonic as the next tone. In Haydn's "Surprise" Symphony, the surprise works because of the listener's expectations that the phrase will cadence normally.

Another important aspect to the role of expectations is that the interplay of making predictions and having them met or not met gives rise to a feelingful response. Persons who can listen with sophisticated musical expectations based on familiarity with the style or musical language in use are more likely to be moved by the music than those who are unfamiliar with the style and who thus listen with no musical expectations. A naive listener who has no expectations as a cadence point approaches, and thus is not aware that the deceptive cadence which occurs is a deviation from what is expected, will probably 'remain unaware of the composer's musical intentions.

The concept of expectations may also help to explain why many do not respond favorably to "modern" music. if a listener can find no discernable melody , rhythm, or other recognizable pattern, and has no idea of what might come next in the music, he or she is likely to stop listening, become frustrated, or respond in some other negative fashion. In fact, this is true of all listening experiences, not just for "modem" music. If a student's musical background, or lack of it, is not sufficient to allow him to detect the patterns in Bach, Mozart, or Beethoven, responses are not likely to be positive.

4. Approach each concept through as many sensory modes as possible.
A single brain cell can be activated from several sensory inputs. Also, areas of the brain, whose task it is to interpret raw sensory information, can receive information from different sensory modes. Thus, approaching a concept through more than one sensory mode will help reinforce learning. For example, a melody can be heard, seen (through a variety of visual representations), and felt (through many types of body movements).

5. To help students remember, present information without interference, make certain it has some meaning to the students, and give them an opportunity to practice the new information.

A. Information is better retained when it is presented with no interference.

Research on memory indicates that interference can disrupt the change from short-term to long-term memory. Imagine you have just looked up a telephone number in the directory and someone speaks to you before you can dial. Now imagine there is a fire drill during a class or rehearsal. Somewhere between these two extremes are the many distractions which can occur during learning. In addition to "disturbances," other kinds of interferences might include presenting too many things to learn at once, conflicting or competing stimuli, or too fast a

learning pace.

B. Information is better retained when it is meaningful.

As has already been discussed, the brain operates on the basis of pattern recognition. When the significance of a pattern is known, it is more easily learned. The simple message for teachers is that when you ask students to learn something (scales, for example), make certain they understand why it is important, and how it fits into the total musical experience.

C. Information is better retained when it is practiced.

As obvious as this statement should be, there are many times when we fail to give students the opportunity to practice that which is to be remembered. Contrast these two situations: (1) Choir Director A says, "You're too loud at letter A; altos, your pitches are incorrect three measures before B; tenors, you are rushing at D and again at N;" and so on all the way through the score. (2) Choir Director B says, "Sing the first phrase at letter A much softer." The choir sings. "Good, much better. Altos, sing your pitches for me three after B." The altos sing, and so it goes throughout the score. The choir director in the second example is likely to be more successful because the students were allowed to practice what was to be remembered.

6. Many repetitions are necessary for fluid motor skills.

The cerebellum is a brain structure which controls muscle coordination. If a motor pattern is repeated often enough, a "program" is stored in the cerebellum which can eventually be run automatically, that is, without conscious attention. An adult signs his name "automatically" because a tremendous number of repetitions have freed him from thinking about the movements necessary to make each letter.

The implication for the learning of musical performance skills is that the More response patterns that can be made reflexive (automatic), the more the conscious brain can be directed toward the overall task. For instance, a young violinist may be in the process of learning to keep the bow parallel to the bridge (a response pattern); yet when she encounters a difficult rhythm, she may lose control and bow at increasingly wider angles from the bridge. An accomplished violinist has made many response patterns reflexive, such as arm and hand positions. finger patterns, and recognition of rhythms. During a recital, many aspects of the performance go on automatically, and the performer is free to consider the total performance and to respond to imperfections, such as intonation problems, with the necessary corrections.

7. Strive for a balance between familiarity and novelty.

When activities become so routine that they are dull and boring, students lost interest. Likewise, when activities are so unfamiliar to students that they have no frame of reference from which to operate, they also tend to lose interest. The reason for this concerns a brain mechanism, the reticular activating system, which determines the significance of incoming sensory information. If the incoming signals bring no new or useful information over a period of time, the conscious brain will cease paying attention to them. If the brain can make no sense of the incoming signals -- because a comparison with past experiences brings no exact or "almost" match -- it will turn its attention elsewhere.

A result of too much familiarity or too much novelty is a condition known as behavioral sleep. Behavioral sleep might best be described as drowsiness or gross inattention. An example of behavioral sleep due to too much familiarity might be during a rehearsal warm-up period where the same exercises have been done in the same sequence for many rehearsals in a row. Presenting new material without relating it to previously learned material, a condition of too much novelty, might also result in gross inattention.

8. Remember that every learning situation has affective as well as cognitive aspects.

Because of the relationship between the cortex and limbic system, we think and feel at the same time. Thus, in every learning situation, students are not only learning facts or skills, but attitudes and feelings as well.

Teachers need to be aware that they are teaching more than course content or specific skills. Body language, tone of voice, the environmental atmosphere -- all communicate feelings that may aid or hinder the learning process. By his enthusiasm, attitudes, ideals -- or lack of these attributes -- a teacher communicates messages that are sometimes more important than the subject matter itself.

9. Strive for a balance between verbal and noverbal learning, between logical and intuitive learning, between analytic and Gestalt learning, and between sequential and holistic learning.

In the enthusiasm over new discoveries about the different roles of the left and right hemispheres, some extravagant statements have been made: "If students don't get music instruction the right brain will atrophy;" "Music is in the right brain." Such statements as these go, beyond the available data and distort the more well-supported findings.

There is evidence that many individuals tend to prefer or are better at one style of information processing (verbal or nonverbal) than another. Also, the contrasting modes of processing do provide different insights, different ways of "knowing." Because of this, and the fact that many, if not all, musical experiences have both verbal and nonverbal aspects, it seems prudent to include both approaches in a teaching strategy.

Summary

Scholars are looking at the relationships between brain research and musical behavior more than ever. No immediate, radical changes in teaching techniques have yet come out of this new inquiry, but new understandings are emerging. Though it is difficult to predict what benefits there may be for music teachers in the future, there are some exciting possibilities. In the meantime, it is important that music educators continue to keep an open mind to new information as it becomes available and to be supportive of those who are pioneering on this new frontier.

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