

Mind, Muscle, and Music

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I have become interested, as a neurologist, in the process involved in the acquisition of musical skill. What is it about the human brain and muscular system that permit the musician to develop the degree of control needed to produce music from an instrument?

I think we should begin by recalling the nature of the device the musician must learn to operate—his musical instrument. Reduced to its basic prosperities, any instrument is imply a resonant device which the musician must manipulate, strike, or alter aerodynamically to produce some sort of sound. The sounds become music when they are formed into patterns of notes whose pitch, rhythm, intensity, and harmonic quality are controlled by the musician.

With respect to the musician, the greatest interest for us is the hand. It looks simple on the outside, but underneath it is an intricate and compact machine of muscles, nerves, bones, ligaments, and joints engineered to permit an unlimited variety of movements. When the musician is operating his instrument, the external movements visible to his audience may be quite simple or quite complex, but underneath there is a fabulous machine at work responsible for the final result.

I might say that the Maseratti

automobile is just a toy in comparison to the hand. You can read the owner's manual and you will know exactly what the car can do. The hand, however, because it is operated by the human brain, is trainable. It will continually reshape, refine, and improve its own performance depending on the owner's experience, training, and goals. There is no manual for the human hand that will tell you its operation characteristics. If there were such a document, it would probably contain the simple statement: "Ask the owner."

MUSICIANS AND ATHLETES

In calling attention to the special nature of the highly skilled use of the hand. I think it is appropriate to comment on the striking similarities found in the situation confronting musicians and another group of specialists in motor system development: athletes. There is very little to distinguish the serious musician from the serious athlete, apart from this: the musician concentrates on perfecting control of the small muscles of the upper extremities (or the vocal apparatus), tends to be stationary while performing, and monitors his own output largely with this auditory system. By contrast, the sports athlete develops mainly his trunk, leg, and upper arm muscles, has to change his location almost continuously in relation to other people and an inanimate movable object, and relies mostly on his visual system to monitor what is happening. In certain sports, most notably gymnastics, ice skating, and ballet, the essential similarity of these physical disciplines becomes apparent.

Proficiency and success tend to come only after long periods of repetitious training, with countless hours spent on drills and exercises which condition muscles and establish

patterns and increasingly complex sequences of movements. These must be learned so well that they can be confidently and smoothly executed whenever needed, automatically.

When the necessary moves have been mastered, the athlete or performer moves to a sort of summit experience—live performance—a vanishing short period of time during which everything must be done flawlessly if the effort is to succeed.

During performance, the athlete confronts a live competitor whom he must outperform if he is to win. The musician confronts an unseen competitor, in the form of another musician who is remembered by the audience as having set a standard for the music being presented. The athlete in competition knows at the end of the contest whether he has won or lost. The musician usually has to wait until he reads the reviews in the paper the next day.

THE EFFECT OF AGE

There probably is one difference between the musician and the athlete that really does count: the effect of age.

For the most part, musicians can look forward to continued maturation and refinement of their skills well beyond the age at which even the most durable football or tennis player has retired to the sidelines. Rubinstein, for example, claimed that he really did not begin to play as he wanted to until he was nearly eighty.

THE BRAIN

We now come to the brain. It is divided into two halves, called hemispheres, that are nearly mirror images of one another. In general, the

right half of the brain controls the muscles on the left side of the body and the left half controls the muscles on the right side of the body. There is a tendency to refer to the left half of the brain as the “literate” half, or the dominant hemisphere. The right side, by contrast, seems to have a greater capacity for non-verbal skills, such as recognizing visual patterns (this is what accounts for the ability to recognize faces, for example) and also for responding to the musical characteristics of sound.

Approximately in the middle of the brain is an infolding called the *central sulcus*. A special feature of this region is that cells which directly activate muscles are lined up just in front of the infolding, and cells which receive information about muscles and joint position are lined up just behind the fold. This means that the part of the brain that has final control over muscle movement will know very quickly whether the intended movement was completed correctly.

A very important part of the control system has been greatly expanded, namely the portion that has to do with regulating the muscles of the hand and the vocal apparatus. In other words, the brain has improved the control system which regulates the small muscles of the body to permit the kind of movements with refined control required for speech, singing, playing an instrument, or doing anything that requires fine motor control of the hands.

Although we are still not completely certain how it works, it seems that the cerebellum works with the motor strip of the brain in regulating the smoothness and the timing of muscular contractions. Obviously, these two qualities are extremely important for musicians. It is particularly interesting to

note that in humans, nearly ninety percent of the cerebellum is set aside to assist in regulation of the movements of the hands and fingers.

BALISTIC MOVEMENT

It turns out that the first important clue to the understanding of extremely fast movements was provided by a physiologist over 80 years ago. In 1895, a man named Richer took photographs of the thigh muscle during a kicking motion. When he studied these films he made an extremely important observation: that the muscles were not contracting or pulling during the entire course of the movement. The same pattern of activity is seen in arm muscles during a throwing motion. They move starts with a single burst of activity in the muscles which launch the limb forward. The muscles then relax, while the limb coasts through the rest of the move. Because of the obvious similarity to the way a bullet is fired from a gun, this has been called a ballistic move.

It is now recognized that all movements of the body, including most of the movements used by musicians in fast passages, are of this type. In considering these fast, or ballistic movements, it is important to understand that before the move begins, the precise details of all the control signals must have been worked out in advance. Since there is no chance to correct mistakes after the move has begun, everything has to be absolutely right from the beginning.

It is now believed that the cerebellum assumes the enormous responsibility of regulating the advance programming of command signals to muscles when they must operate in long sequences with precision control, as is the case in musical performance.

ESTABLISHING PATTERNS

There has been a great deal of speculation among physiologists about the exact way the cerebellum works together with the motor strip to coordinate fine motor activity. The most current thinking is that we begin to learn how to make complicated moves rather laboriously—working out the details, step by step, making corrections when we observe our own mistakes, and by consciously and deliberately establishing patterns of movements (sometimes coaching ourselves verbally as we go along) that eventually become less tentative, and finally become smooth and sure.

In the case of music, when the movements have been practiced in such a way that they are completed correctly, virtually all the time, the brain shifts to a ballistic strategy. It is as if the conscious mind is saying “I’m tired of slaving over the details; now let the cerebellum do it. I want to stand back and watch!” And, the conscious attention of the musician shifts from the mechanical details of performance to the esthetics. As it turns out, this is a good thing, because although the cerebellum may be just a dumb slave to the conscious brain, it is infinitely better at running the muscular system when speed and smoothness are essential. If you don’t believe that’s true, just ask any musician what happens during a performance when he starts thinking about the details of what he is doing physically.

When the conscious brain steps in and tries to take over, everything slows down, tone control becomes erratic, timing irregular, and notes tend to appear out of sequence. The musician may become intensely aware that his hands are shaky, perhaps cold and moist, and the muscles slow and stiff. That is not his imagination—both the

smoothness of the control system and the responsiveness of the muscles are different when the conscious brain overrides the cerebellum.

PRELIMINARY CONCLUSIONS

I would like to share with you some preliminary conclusions I have reached about music education.

First, it seems that a close examination of the “tried and true” principles of music teaching shows them to be compatible with what we are now discovering to be the operating characteristics of the human brain and neuromuscular system. Whether or not they actually understand the underlying physiologic or psychological principles, good teachers have found didactic techniques that optimize the natural learning system built into the human brain. I can’t help believing that a wider appreciation of the operating characteristics of the nervous system will help make teaching systematically better.

Let me give you two small examples of what I mean. Slow practice is the key to rapid technical progress. The cerebellum is a nonjudgmental part of the brain; it assumes that any repetitive activity in the muscular system is being repeated because the conscious mind is trying to make it automatic. And, the cerebellum will be just as efficient an automatizer of incorrect sequences or timing as of those that are correct. When practicing takes place at a pace too fast for accurate playing, there is very little chance for the material to be mastered, and reliable, confident performance simply will not occur.

It is probably true that practice for speed is seldom necessary. The cerebellum can supply all the speed

wanted if patterning is correct during practice.

MENTAL PREPARATION

A second teaching principle which stands on a sound footing has to do with mental preparation. By this I am referring to those aspects of study or preparation which take place away from the instrument or which are used to make rehearsal simulate live performance conditions. Students at Julliard were told to practice their music away from the piano, and my association with the teaching staff of the Concord (Calif.) Blue Devils Drum and Bugle Corps made me aware that they use similar techniques in preparation for competition.

It turns out that serious athletes are now being trained to do the same thing. A technique referred to as Visual Motor Behavioral Rehearsal (Richard Suinn) has been shown to help skiers, runners, weight lifters, and others improve their limits and to discover small technical errors that adversely affect performance. These techniques work not simply because they help performers cope with stress and performance anxiety, but because they facilitate programming of the cerebellum.

Mention of the training of athletes brings me to my second general preliminary conclusion about music teaching. I believe there is great immediate relevance and value in the recent written work of psychologists who have been assisting elite athletes and their coaches, and I would recommend this seemingly unusual resource to your attention. The first glimmer that athletes might have something in common with musicians came to me after reading Timothy Gallwey’s book, “The Inner Game of Tennis.” and since then I’ve spoken with Richard Suinn, psychology professor at Colorado State University and a consulting psychologist to the U.S. Olympic Team, and to Robert Nideffer, a psychologist in San Diego

with similar interest in athletic training. Both have written excellent books dealing with mental aspects of athletic performance, and what they say to skiers and weightlifters makes perfect sense in the training program of musician.

Third, I think it is useful to acknowledge that there are three distinct groups of music students, each with special opportunities and problems, each needing a special approach.

The first of the three groups is children beginning in music. They are being exposed to a rigorous, integrated physical and mental discipline possibly for the first time in their lives, and they will inevitably transfer both positive and negative experiences to subsequent structured learning situations they encounter. Music teachers, therefore, have an opportunity and I think a responsibility to provide the child with a model, or a set of protocols, for positive attitudes and strategies in their own future education.

The second group of students is adults who approach music as a potential long-term recreational interest. My suspicion is that many of these students set unrealistically low goals for themselves because they were brought up thinking that music and athletics were the special preserve of people who had unusual gifts or talents. There are special challenges and opportunities in this group—the opportunities having to do with the incredible lift adults get when they are given a glimpse of their own potential. If you doubt the truth of this notion, you haven't noticed all the people jogging in your neighborhood lately.

The third group consists of both the adults and children who have a genuinely special aptitude for music. These are the people who progress technically at an unusually rapid

pace, or whose personal sensitivity or charisma, and ability to communicate musically, mark them as potentially successful performers. They obviously have an extra set of requirements in their training, since survival in the competitive musical world demands a carefully developed, long-term plan and unusual commitment from their teachers. They may also need special personal attention to reduce the risk of early social isolation

