CHAPTER 4

BACKGROUND OF OUR STUDY

Having had a glimpse at the historical background of our material, we now note briefly the general background of the studies we propose to carry out. Our agenda includes: Relations between musical sounds and mathematics, and their implications for scale construction and tuning; Physical properties of modern musical instruments and their implications on how those instruments should be played and constructed; Physiological facts about the machinery of fingers, wrists, and arms, and their implications for achieving control and endurance; Summary of the techniques and pedagogical principles of the great musicians of the past; The writer's personal comments on musical performance and composition. They need not be read in this order.

Before turning to the specific details of this program, we set forth our general aims, the general attitude toward them, and the general state of knowledge that we have available to bear on them.

What Do Scientists Really Know?

The writer of a book like this faces a small dilemma. On the one hand scientists know, with a degree of certainty virtually unknown in any other field, what physical laws govern the behavior of musical instruments; and we know that this information could be of great help to a musician learning how to play the instrument, or a craftsman trying to make a better instrument. A person who persists in believing what is not true or disbelieving what is true, can waste a lifetime of effort on something that is without hope of success.

On the other hand, musicians and craftsmen with no scientific training often do not believe us, or even fear that scientific knowledge would be in some way harmful to their musical goals. How do you help a person who does not want to be helped?

Our major problem is not in convincing others that something is possible; but in convincing them that something is impossible. Therefore let us emphasize: when a scientist makes a statement that something is or is not possible in a musical instrument, he is not merely expressing a personal opinion. He is stating the result of a great deal of experience, supported by thousands of quantitative experiments, carried out over Centuries. It is this continual *recording and accumulation* of evidence that makes us so confident.

But our evidence does not pertain only to the case at hand. The same law of composition of forces that determines whether the body of a violin can stand the 50 pound stress, applied to it by tightening the strings, without breaking, also determines whether a steel railroad bridge can carry its thousand ton load without collapsing; or whether a spider web can support the one-tenth ounce weight of a beetle without tearing. The same (Newton's) law of motion that determines the vibration frequency, and thus the pitch, of a violin string playing the note A 440, also determines the thousands of times longer vibration period of a mile long suspension bridge, and the ten thousand times shorter vibration period of the quartz crystal that regulates the speed of a wristwatch.

In other words, the laws of physics that are relevant to the behavior of musical instruments have all been verified accurately, innumerable times, over ranges of size, time, and forces from thousands of times greater to thousands of times smaller, than those occurring in musical instruments. Therefore, scientists have become very confident about the correctness of those laws, and we have no hesitation in pronouncing certain beliefs about musical instruments to be false superstitions or folklore.

Among these are the very persistently held beliefs that a musician can change the tone quality of a piano, without any accompanying change in loudness, by pressing the keys in different ways, that a certain microscopic structure of wood cells is essential for a good sounding–board, that the tone quality of a Stradivarius violin is due to details of the grain of the wood or a secret varnish known only to him, that a soloist can, by a conscious effort of the will, "throw" his tone to the rear of an auditorium, etc. I have heard every one of these claims, and many others equally false, expounded in full seriousness by competent musicians or instrument repairmen; and been laughed at when I tried to explain why it could not be.

Often, for people without scientific training, it has simply never occurred to them that a cause–effect relationship requires a physical mechanism to bring it about. Like an oboist we knew who believed, with absolutely unshakable certainty, that he could project his sound by an act of will in any direction, they tend to be so sure in their own minds that they brusquely dismiss all attempts of scientists to explain to them why the relation could not exist. He was, in effect, claiming for himself a power of psychokinesis that transcends all physical law (although he would have laughed at anyone who made pretension of such powers in a non–musical context).

Sometimes when we try to explain the impossibility of something, we get the response, "They laughed at Edison, too." Indeed, it is true that clever inventors have made fools of people who were too quick to claim that something cannot be done. But note the difference: those who laughed at Edison were, far from being scientists, quite ignorant of physical law. If what you believe or want to accomplish does not actually stand in violation of known laws of physics, then a prudent scientist will refrain from claiming that it is impossible (although in the heat of argument anyone may blurt out something that he regrets later).

Persons without scientific training have no comprehension of the amount of evidence we have supporting our claims; and tend to dismiss them as being mere opinions of someone who lacks *their* experience. To anyone who holds that attitude, let me point out this: if you can prove the incorrectness of any of our present laws of physics, by definite experiments described in sufficient detail that others can reproduce them and verify them independently, you will not be scorned by scientists (like the whistle–blower in a Government agency, who is ostracized for pointing out the defects of the system). On the contrary, you will be admired, will undoubtedly receive a Nobel Prize in physics, and your name will go down in history as a great discoverer. That is how scientists operate, and how confident we are of our present laws.

A Two–Way Street

But our communication problems are not only for a scientist trying to explain something to a musician; they may be even worse for a musician trying to explain something to a scientist, even when both are trying their friendly best to accomplish that communication.

For example (a real example, in which the writer has participated several times), consider a musician trying to explain to a scientist what property of a violin is most important to him. A musician without scientific training just does not have the vocabulary to do this, and is unable to communicate any definite facts to the scientist, because he does not distinguish between what is a real property of the violin, and his own feelings while playing it. Almost always, his own private sensations are believed to be a real property of the violin. The violin will be described as having a "good tone" or a "bad tone" but the scientist does not have the slightest idea what is meant by that because it is not an objective statement of fact.

The only way to break this communication block is to have a person who is an experienced, sensitive musician *and at the same time* is a trained scientist, able to judge from his knowledge of physical law what is a real property of the violin and what is his own sensation.

Finally I had the opportunity to talk with a very good violinist, who was also a scientist and had thought about these problems. He was able to communicate to me things about a violin that no musician could. What a violin player really wants, it turned out, is an instrument that speaks out, immediately, reliably, loudly, and above all *uniformly* on all notes. An instrument that does this will probably be described subjectively as having a 'good tone', because it sounds good to the player to get an immediate, predictable response to what he does.

Of course, an extremely harsh tone will be noticed eventually; but it is surprising how much musicians will tolerate it. The writer once heard a string quartet performance in which the cello had such a harsh, scratchy tone that it was physically painful to listen to; yet the famous cellist was perfectly happy with it, because the instrument responded well to his commands.

We realize, then, that what a violinist reports as a 'good tone' could be as much a matter of the condition of the bow, or the smoothness or roughness of the strings at the bowing point, as anything in the mechanical construction of the instrument.

Beware of Illusions!

But even a trained scientist can confuse his own sensations with reality if unchecked. The writer can understand how this happens, because he has had the experience several times. For example, in playing the first movement of the Beethoven piano sonata Op 26, a musician told me that I was overemphasizing a certain chord, destroying the musical sense. I simply did not believe him, because it did not sound that way to me. But later I listened to the objective evidence of a tape recording of my playing, and it was obvious that he was right; I *was* playing that chord much too loudly, but the fact that I was pressing the keys at the same time had changed my perception of its loudness.

After that experience, I made a habit of checking everything I played with tape recordings, so I could compare my subjective experience while playing with the objective fact of the sound it was producing. But after a few years of this, I had myself 'calibrated' well enough that the tape recorder was no longer needed; thanks to this training I now know, at the moment of playing, what effect I am producing in the ear of the listener.

From this experience there emerges the following advice. There is a certain stage in the training of a musician (the mechanics of playing under fair control, attention turning to interpretation), when listening to tape recordings of your playing will help more than can any teacher or long hours of practice. This is the only way you can know objectively what sound you are producing; therefore the only way you can know what needs to be changed. Without this experience you could practice forever – as I would have – perhaps improving your technical facility, but without improving your actual musical performance.

Illusions are notoriously easy to produce in all areas of perception. A famous example concerns blind people, who when questioned how they detect and avoid obstacles, report almost unanimously and with total confidence, that they feel a pressure on their faces that warns them of the obstacle ahead. A scientist, seeing at once that there is no physical mechanism that could possibly do this, then conducted carefully controlled experiments to determine the true means in use. It was found that when a mask was placed before the face, unknown to the subject, he still found the obstacles just as well; but when his ears were plugged up he lost the ability to navigate around obstacles.

So, just as the scientist suspected from the start, blind persons are actually using *sound* echoing off those obstacles, to orient themselves (just as bats do, skillfully avoiding obstacles and catching insects, while flying about in the dark).

Our point is this: it certainly does not help a blind man to be in ignorance of the means by which he gets around – indeed, the necessary first step toward improving his ability to do this is a conscious understanding of what he is really doing.

It is exactly the same in music. However much a musician may cherish the illusion that he has a "singing touch" that can alter the tone of a piano at will, or project his sound at will to wherever he wants it to go, the holding of such illusions cannot possibly help him to perform music more effectively. On the contrary, he will be wasting effort on nonproductive things; indeed, to carry a false mental picture of what he is doing, could very well prevent him from doing what is necessary to improve his musical performance.

The first step toward improving his effectiveness is a conscious understanding of the real facts concerning what is and what is not happening in a musical performance.

But may not some illusions be harmless? Sometimes they are. There is plenty of evidence of people who cherish illusions and are nevertheless perfectly good musicians – that oboist was an example. But he was a good musician not *because* of his illusions, but *in spite* of them. How many musicians remain mediocre performers or unsuccessful teachers, because their illusions prevent them from learning, or explaining to pupils, what is really essential in musical performance?

It is not really exaggerating to way that a musician's life, in its physical aspects, is one of *total immersion* in evidence for the correctness of our understanding of physical laws. His comfort and safety depend on the fact that the known laws of physics are valid over ranges of conditions vastly beyond anything in his direct experience. And yet, he may doubt, and teach his pupils to doubt, that those same laws apply to his piano!

A view which we have heard several times runs like this: "Your scientific theories and instruments reveal part of the truth, but not all of it. My trained ear is far more sensitive than your cold, unfeeling instruments, and I can hear differences in tone quality which are far too subtle for your instruments to detect."

To this, the proper reply is: "Our instruments are vastly more sensitive than your ear. Can you, after hearing a piano note, tell me just what happened in the first thousandth of a second after the hammer first touched the string, what happened in the next thousandth of a second; and the next? Our theories predict, and our measuring instruments verify in minute detail, exactly what happens in every thousandth of a second throughout the process of hammer rise, striking the string, and tone production. Without the slightest difficulty they can reveal differences in sounds that are totally beyond the ability of your ear, or anybody else's, to detect. Our instruments are indeed cold and unfeeling; and it is just for that reason that they can reveal the truth. They are never confused by the illusions and emotional factors that are distorting your personal judgments."

The whole success of science is due to the fact that scientists have learned to recognize frankly the *unreliability* of our own personal judgments. While no scientist can – or should – disregard such feelings entirely, he knows that major reliance must be placed on evidence obtained by completely objective means.

Many other fields of inquiry would benefit if there were more widespread recognition of the unreliability of personal judgments. For example, an economist who is emotionally committed to upholding one particular political philosophy, and insists on interpreting everything in terms of his own political value judgments instead of the real facts, is thereby automatically prevented from learning the true laws governing economic activity, and from making any real contribution to economic knowledge.

The scientist must, however, concede at least this much: knowledge of the objective facts concerning tone production in a piano will not necessarily make one a better musician (otherwise every physicist could become a superb pianist!); conversely, a lack of such knowledge does not necessarily prevent one from becoming a good musician, as the evidence demonstrates abundantly. But the valid and important point to be made is this: a dogged belief in demonstrably false ideas concerning a piano cannot possibly *help* anyone to master the instrument; it can only delay this mastery by misdirecting our efforts. It is for this reason that a musician ought to be aware of the objective facts concerning the piano's operation.

Furthermore, as scientists we must always admit a small possibility that we might be wrong. Certainly, if some utterly unexpected and startling new evidence were found, we would not cling doggedly to past beliefs, but would change the way we state the laws of physics so as to accommodate the new facts. How greatly civilization would benefit if some others, who have far more need of it, were willing to make the same concession!