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CHAPTER 5

MECHANICAL FACTS OF PIANO PLAYING

The writer witnessed an interesting demonstration of contrasting piano techniques at a concert at the University of Minnesota in November 1959, at which Robert and Gaby Casadesus played the Mozart Concerto for two pianos, K 365. He, with presumably greater native strength, wasted it with unnecessary motions; when a crescendo was called for, he worked visibly harder, raising his hands higher and striking the keys more percussively; but this strategy met with very little success.

She produced just as loud crescendos without any such exertion. The reason was visible only because she wore a sleeveless gown. In the loud passages one could see no difference at all in the motions of her hands, but the muscles on the back of her arm stood out; she had learned to keep her hands on the keys, but simply to press harder using the strength of the large arm muscles to do the work.

A physicist or physiologist could have told them that this is not only the most efficient from the standpoint of muscular effort and fatigue, but also the best controlled, way to produce piano sound. In the present Chapter we support this observation by studying what is happening in the piano mechanism; and in Chapter 6 we examine what is happening at the same time in the hand and arm. Both areas reveal surprising, and little known, things that can be important to a pianist trying to improve control and endurance.

How Should A Piano be Played?

It is a basic fact of Nature that no mechanism – from a mosquito wing to a human hand to a bulldozer – can be under full control when it is being strained to the utmost; some reserve strength is necessary. One observes this constantly in any athletic activity, from basketball to skiing to swimming; the athlete who has learned to move in the most efficient way, using each muscle only to do what needs to be done and in proportion to its strength, so that it is accomplished with minimum exertion, has a great advantage in accuracy and endurance over one who wastes energy with unnecessary motions or who uses weak muscles, easily fatigued, to do what strong muscles would have done better without fatigue.

When in the 1930's José Iturbi raised his hands high above his head to come crashing down upon the keys, when in the 1960's Glenn Gould was tossing his trembling hands high after a staccato, and when in the 1980's André Watts was snapping his hands away from the keys and downward as if they were red hot, none of these gestures had the slightest effect on the actual sound produced – except that all were wasting muscular reserves and therefore inevitably losing a little bit of the precise control that they might have had otherwise. Of course, the loss was not serious and for most pianists it would hardly matter; but it was nonetheless real, and at the peak of the virtuoso performance scale it becomes crucially important.†

† In exactly the same sense, for a mediocre pole vaulter a small change in efficiency hardly matters; but for the champion pole vaulter, winning or losing can depend on being able to squeeze just one more inch out his clearance.

The pianists with the most perfect control over dynamics and timing are the ones who have learned to keep their hands on the keys, relaxed, never moving a finger except when it serves the musical purpose. For rather obvious reasons, this habit is also necessary to achieve the greatest accuracy (put bluntly: hitting the right notes), and to produce the smooth legato phrasing without which it is impossible to play Beethoven and Chopin properly.

But this efficient use of one's hands at the keyboard does not come naturally, any more than does the proper handling of a violin bow or the proper plucking of a harp string; all require careful explanation from teachers and then conscious effort and practice, to achieve. When there are many ways of being wrong, and only one way of being right, a beginner is very unlikely to happen onto the right habits by lucky chance – and practicing the wrong habits does more harm than good, very rapidly. This has been very well established in many different athletic activities.

Athletic Performance

Scientific study of athletic performance and the best way of achieving it, has been underway for some sixty years. The principles are the same as those involved in pressing a piano key but the scenarios, involving longer distances and times, are easier to visualize.

In the 1930's Claude Jerome Lapp, a Professor of Physics at the University of Iowa, studied the design of archery bows with the aim of finding how to achieve the greatest arrow velocity with the least muscular strength. Ordinarily, one would expect that the force required to draw the string a certain distance would be proportional to that distance, as we find for ordinary springs; this rule is called "Hooke's law" by scientists. But with a Hooke's law bow the muscular strength required would be the *maximum* force, which is actually exerted on the arrow for a miniscule fraction of the time it is being pushed by the string.

Obviously, it would be far more efficient if one could design a bow which required, as nearly as possible, a *constant* force, independent of distance, to draw the string; for then that same force would be exerted on the arrow throughout its acceleration by the string. This ideal bow would enable one to achieve a given arrow velocity with just half the muscular strength required by a Hooke's law bow – and consequently greater control and endurance. Lapp succeeded in finding a way of tapering and curving the bow (back–curved at the ends) so that this ideal was rather well approximated; and this enabled his daughter to win many prizes in archery. The Lapp bow design, or one based on it, is now more or less standard for tournament archers.

The same principle was then found in a study of efficient performance of members of rowing teams, a popular sport in England and Australia. Physicists measured the force exerted on the oar at different points of its travel, by various crew members, and Fig. (5.1) illustrates what was found. Here we plot the distance moved by the oar horizontally, the center of the diagram being the point where the oar is perpendicular to the boat (or rowing shell). The corresponding force exerted on the oar is plotted vertically. Curve A represents the instinctive performance of almost all rowers; they start out gradually, increasing to a maximum force at the middle of the stroke, then taper off gradually. The area under the curve is the total energy that has gone into propulsion of the shell.[‡]

But one crew member was smaller and presumably not as strong as the others, and there was some concern about whether he was able to "pull his fair load." However, his force – distance curve turned out to be the B curve; he started out vigorously at the beginning of the stroke, exerted nearly a constant force for most of it (although less than the maximum force exerted by his teammates), and continued this nearly to the end of the stroke. But the areas under the B and A curves were the same; he was actually contributing just as much propulsion as anyone else, *and he was doing it while contributing less to the total weight of the shell and using about half the muscular strength.* A crew of rowers like him would win easily over a conventional crew. Needless to say, this discovery resulted in some changes in the selection and training of rowing crews.

The same kind of effort analysis has been applied to pole vaulting, and it has resulted in adding about two feet to the recent Olympic records. Active studies of this kind continue at many places; Colorado Springs, Calgary, Spain, and Australia among others. They have studied in detail the efficient ways in broad jumping, swimming, bicycling, and practically every other such activity; today an Olympic Gold Medal is very unlikely to be won unless the athlete has had the benefit of training by a coach who understands these things.

The Pressing of a Piano Key

The problem of finding the efficient way of pressing a piano key is almost identical with the above ones, and attention to it will produce the same kind of results – as Gaby Casadesus demonstrated (perhaps unwittingly). Now let us justify these general remarks by a closer examination of the process, both mechanical and physiological, of pressing a piano key.

Here it is much harder to be consciously aware of what one is doing, because it is all done in a fraction of a second, and the maximum travel of a piano key is only about 3/8 inch (and the useful pushing of the hammer occupies only about 1/4 inch of that key motion, compared to about 6 inches for the archer, and 3 feet for the rower). None of us has naturally the perceptiveness to know what kind of force–distance curve we are producing, and no teacher can tell this merely by watching us play; so we need conscious practice guided by understanding of the physical facts.

************************** MUCH MORE HERE! *****************************

‡ More technically, it is the increase in the kinetic energy of forward motion of the shell, contributed by that oar stroke.