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THE NECESSITY OF QUANTITATIVE APPROACHES IN PIANO EDUCATION[1]

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ABSTRACT

This study aims to reveal the necessity of new approaches to make virtuosity more achievable in piano education. Although the piano is very large, very expensive and very difficult to carry compared to most instruments, it is one of the most widely used and most demanded instruments in the world. Contrary to this demand, this instrument, which initially belonged to the upper class but later became popular for all humanity, has evolved throughout history becoming more and more difficult to play. Despite this difficulty, there are pianists called virtuosos, and the secret behind their artifice has not been revealed within the traditional piano education. Today, with the help of technological opportunities, the skills of virtuoso pianists can be examined with quantitative methods, and the findings that emerge under the light of these examinations can provide reliable suggestions to the piano education like never before. Although there are some limitations of these quantitative approaches, which can also be called piano science, and there is a resistance to scientific method's existence in traditional education; the piano virtuosity will become an achievable goal by many more pianists with a more efficient piano education system that will improve with the help of today's technology and scientific method.

Keywords: piano science; scientific method; virtuosity; piano education; sensor; piano; pianist

PİYANO EĞİTİMİNDE KANTİTATİF YÖNTEMLERİN GEREKLİLİĞİ

ÖZET

Bu çalışma, piyano eğitiminde virtüöziteyi daha ulaşılabilir kılmak için yeni yaklaşımların gerekliliğini ortaya koyma amacı taşır. Piyano, çoğu çalgıya göre çok büyük, çok pahalı ve çok zor taşınır olmasına rağmen, dünyada, en yaygın kullanılan ve eğitimi en çok talep edilen çalgıların başındadır. Başta üst sınıfa ait olmasına rağmen sonradan tüm insanlık için popülerleşmiş bu çalgı, bu talebe tezat oluşturacak şekilde, tarih boyunca, icrası gittikçe daha zor olacak doğrultuda evrimleşmiştir. Bu zorluğa rağmen, virtüöz diye adlandırılan piyanistler vardır ve bu virtüözlerin hakimiyetlerinin altında yatan sır, geleneksel piyano eğitimi dahilinde açığa kavuşturulamamıştır. Bugün teknolojik imkanlar yardımı ile virtüöz piyanistlerin

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becerileri, kantitatif yöntemlerle incelenebilir ve bu incelemeler ışığında ortaya çıkan bulgular, piyano eğitimine daha önce hiç olmadığı kadar güvenilir önermeler sağlayabilirler. Piyano bilimi diye de adlandırılabilecek bu kantitatif yaklaşımların bazı kısıtları ve geleneksel öğreti içinde yer bulmalarına dair dirençler mevcut olsa da; piyano virtüözitesi, bugünün teknolojisinin yardımıyla geliştirilecek daha verimli bir piyano eğitim sistemi ile çok daha fazla piyanist tarafından ulaşılabilir bir hedef haline gelebilecektir.
Anahtar Kelimeler: piyano bilimi; bilimsel yöntem; virtüözite; piyano eğitimi; algılayıcı; sensor; piyano; piyanist

1.INTRODUCTION

Piano with its historical context and technology is an exclusive machine that the humankind created. It maintained an efficient point for flourishing of famous pianists who are maybe the first pop stars of the history. That era was nineteenth century which is known as the rise of individualism and the piano was the ultimate device to express the inner self and also the physical capacities of the individual human with its vast frequency spectrum, extremely dynamic range, incomparable polyphonic opportunities and horrifying but also elegant surrealistic shape. Having such properties, the piano has been had maybe the most well-instituted education from these days on but on the other hand, incorporation of scientific approach in piano education did not proceed as it is expected.

Otto Ortmann gives scientific explanations for playing piano, investigating kinematics of piano keys and the touch types (Ortmann, 1925: 15). Various scholars have continued trying to explain how to play piano better. Unfortunately, this attitude could not find its place in piano world and dominance of tradition survives even nowadays. Mimaki, says that pianists don't know the physiology of piano technique, lack the ability to diagnose technical problems with the piano and make adjustments to their technique, do not have vocabulary to communicate their needs, do not listen to the sound that the piano is producing, relying more on touch than sound (Mimaki, 2010: 4). According to Parncutt, student pianists have lack of information on piano playing. They don't know how the human body and the piano works, how the timbre changes in a particular piano, the noises of piano, the voicing of chords so the pianists may called to be intuitive rather logical (Parncutt, 2007: 23).

It is said that, a contrasting situation of musical performance relative to sports is a lack of scientific studies, which limits making musicians accomplish emotional and virtuosic performance without developing injuries (Furuya et al., 2012: 27). Scientific method's definition in Merriam-Webster Dictionary emphasizes the collection of data through observation and experiment, the formulation and testing of hypotheses (https://www.merriam-webster.com/dictionary/scientific%20method, 05.10.2021). But, mostly, the knowledge on how to play the piano is not based on tested hypotheses. If sport science could become highly utilitarian today, there should be a systematic, quantitative and cumulative knowledge for piano also which can be called as the piano science.

2.THE NEED FOR BETTER RECORDINGS, BETTER PERFORMANCES, BETTER TRAINING

In order to compare today's interpretations with the past, one should refer to today's hifi recordings, early recordings, the scores, letters of composers and their pupils', etc. The music scores hand written by composer and iteratively published by companies gives hints on performances of the pieces at those days. Early recordings had made under certain circumstances and have to be evaluated under consideration of these constraints but still they are the most precious information links the performance tradition before recording age to today. And today, although we have highest resolution and bitrate that can be considered as high fidelity to real, facilities served by technology made us think twice if it is close representation of real or a utopic hyper real. Joyce Hatto, was once thought of greatest pianist of twentieth century turned to be the greatest music fraud ever (Finell, 2008: 32). Opportunities served by new technology made her husband to be able to manipulate other pianists' recordings and label them as by Hatto. Interestingly, there are people (the kenners of today) still prefers these interpretations to their originals. Not only Joyce Hatto, but also almost all classical music recording industry uses DAW's (digital audio workstation) overdub facilities. Recording by section to section, again and again then choosing the best ones and gluing them together became standard procedure. These raise the questions like if they can not play from beginning to the end as they want, how they want to play but can not, what their desired image of music, the ideology is and what the source of it is. One can trace back to philosophy Schopenhauer at that point but if we swim close to the surface, one of the reasons of these efforts lay behind the change in piano mechanism.

The debate over whether the technology effects the ideology or vice versa has not ended yet. In our concept the ideology is the music, particularly, the way of playing piano. Thus, the piano as a machine is our technology parameter and it is constantly evolving since Bartolomeo Christofori (1655-1731) pioneered the musical instrument called pianoforte, which has an action that enables playing different dynamics within a single keyboard, first time. If we turn to the debate on technology versus ideology, so piano action design versus interpretations of music, it is hard to define which one influences the other more but the change in both of them is obvious through the history.

Piano mechanism, the technology, changed over years, mostly towards louder. And a piano, which can sound louder, had to some sacrifices. So, the modern piano has disadvantages to play classical piano repertoire over the pianos used during the creation times of that literature. The ideology pianists seek after today with the help of the technology is the traditional virtuosic playing which is more difficult to achieve with modern piano. On the other hand, there still exist super virtuosos today performing astonishingly.

Since the era of pre-recorded music, population of the world highly increased, piano music became more global and achievable by various social classes so the number of piano players increased but the proportion of players who can achieve the traditional playing regarding tempi, dynamics and sonority decreased. It is said that, even music

schools do not consider the tempo markings by Chopin in his etudes compulsory to achieve. But, although they are small in ratio, there are human beings who can do it regardless of their age. Twelve years old George Li can play Chopin op.10 no.2 with 152 bpm (beats per minute) despite of the disadvantage of his small hands and weak muscles if we compare with an adult (https://www.youtube.com/watch?v=2eqCRr-mI-0, 06.10.2021). It is even higher than Chopin's tempo identification on the score which is 144 bpm. It is easy to find other extraordinary performances like this via searching the Internet. The main question is how this less amount of pianists can still reach that ability to express that ideology although the change in piano technology made fewer amounts of people achieve it.

Vladimir Horowitz carried his own piano which has hammers had been replaced with lighter ones. "Horowitz required precisely 44 grams of key resistance, but full-size hammers were too heavy for an action of this gram-weight; the average Steinway is weighted to approximately 50-55 grams. The result is an extremely fast action that is difficult for most pianists to control at first because they are accustomed to other pianos that have greater resistance to the fingers." (Hughes 1996, as cited by Mimaki, 2010: 35).

Glenn Gould made his technical adjust the aftertouch of his piano extremely close to strings. This resulted frequent wearing out in mechanism but he could accept this challenge.(Mimaki, 2010: 40) Joseph Hoffmann who is the first perfect virtuoso pianist and Daniel Barenboim used a piano with narrow keys due to their small hand size (https://paskpiano.org/keyboard-history/, 29.09.2021). Moreover, pianos are still changing. The technical playing of past pianists cannot be referenced directly. One should consider the changes in hammer size so the touch weight, string thickness, key depth vs. It can be said that earlier pianos were easier to play. But still people needed to search for helpful devices that claim being useful for better technique. Virgil Practice Clavier from nineteenth century, was sounding only a click sound but the resistance of the keys could be adjusted up to enormous degrees. Logier's Chiroplast, Herz's Dactilion, Martin's Chirogymnast, Retif's Ochydactyl are devices invented in order to assist gaining flexibility and true hand posture for piano playing in a shorter time than practicing along. Today, Faulhaber Company presented a machine that gives extra power to touch strike so pianists can achieve more virtuosity with the help of it (As a result, although famous pianists have great ability to play the instrument, they searched for more ways to gain more dexterity. If one wants to make a scientific investigation on piano technique, s/he should approach to the famous pianists and old pianos regarding these aspects.

In fact, all the piano playing methods carries students up a degree but the mystery is how top virtuozos like Arcadi Volodos, Yuja Wang, Lang Lang, Marc Andre Hamelin, Martha Argerich, Daniil Trifonov are able to play this way. They are playing the same pieces as all other pianists in the world do but they can ¨better¨ . They are the most famous pianists and the most distinctive feature of them is their high level of technique and wide possibility to interpret the pieces coming from their technique level. Building a new piano education system upon data gathered from skillful pianists by quantitative methods that can be called as piano science has big potential for more effective piano education

3.QUANTITATIVE METHODS FOR THE PIANO SCIENCE

Today, with developing technology, measurement methods are more various, more accurate and more affordable and these started to be used for clarifying piano technique. While optical or magnetic motion capture systems can give data of changing positions, EMG (electromyography) is a good source to draw a line for neuromuscular activity. Focus detecting binoculars, high definition slow motion cameras, Microsoft Kinekt type depth sensing gesture tracking systems and old reliable MIDI data are among tools that can give us quantitative information on what is going on during playing.

Data is interpretable than ever before and having living super virtuosos despite of over-loaded evolved modern piano makes scientific research on this topic extremely important to understand how piano can be played more efficiently. Having this efficiency enables more varied interpretations of music. Scientific investigation of piano technique through virtuosity perspective has the potential of redefining piano pedagogy. With the help of this knowledge, pianists can achieve the music desired by the composers and also themselves. This has a potential to build a new language for piano playing. In order to maintain the piano education standard close to the virtuosic piano playing, there is a need to reconstruct piano education based on new technological findings.

Each type of measurement tool has advantages and disadvantages over the others. But the motion capture systems are today's trend for academic research in this topic. Motion capture is a technique that has several transmitter units that has to be placed on moving parts of the body and a receiver. The receiver gathers position information from the transmitter units and sends this bulk of data to computer. In computer one can use statistical methods like ANOVA, draw graphics or even animation of that particular playing. The accuracy of motion capture systems is up to 0.1 millimeters spatial and 4-8 milliseconds temporal. There are two primary types of motion capture systems. The optical motion capture has reflective markers as transmitters and infrared cameras as receiver while the magnetic motion capture uses little metal dots and a metal detector type receiver. The main advantage of magnetic type is optical system's proneness to light interference. On the other hand magnetic type can not measure in the presence of metal objects which have to be replaced by plastic or wooden materials. Also the markers are placed on the joints in optical system but magnetic one has advantage of placing markers on middle of the bones so they are more robust. (Rahman, et al., 2011: 23) In the experiment of Goebl and Palmer, optical motion capture is used. Results show that to perform at very tempi, finger movement efficiency is especially vital. To achieve the high levels of timing and force precision common among professional musicians, who develop piano technique through decades of practice, substantial movement control of skilled piano performance is necessary (Goebl & Palmer, 2013: 9). In the work of Kelley, there are ten pianists and optic motion capture technology. Four of two subjects eliminated from analyses because of technical problems occured during tracking and collection of data. Results claim that despite the fact that the findings did not differ considerably between the two groups, The traditional-trained individuals' standard deviations were higher than those of the Taubman-trained subjects, possibly indicating that the Taubman

pupils' movements had lower amplitudes (Kelley et al., 2010: 2). According to Tits, the eigenvalues, which indicate the contribution of each eigenmovement in the original movement, allowed pianists to be compared to one another and revealed that highly skilled pianists used more eigenmovements, indicating higher hand motor control. Four pianists who are playing piano 15 ± 6 years participated in the experiment done with twelve motion capture cameras and twentyseven reflector points in each subject's hands (Tits, et al., 2015: 104).

General experiment setup includes a MIDI data recording too. MIDI is the acronym of musical instruments digital interface. MIDI data has on and offsets of keypresses with velocity (Maidhof, et al., 2014: 185). This velocity data has a 7 bit of resolution in most digital pianos but Bosendorfer CEUS supports 8 bits of data measured directly from hammers (McPherson, 2013: 152). It is really beneficial to synchronize motion capture data with MIDI but the main constraint of MIDI is its discreteness. In an experiment, EEG (electroencephalography) is used to measure brain activity during piano performance. In order to synchronize music with EEG data, MIDI data is recorded in the same time. (Zamm et al., 2017).

Instead of MIDI, McPherson developed an alternative system that can measure the movements of keys continuously. It is based on Moog piano bar which is an optical measurement system can be installed on any piano in order to gather information like MIDI. But instead of MIDI, this system can give us the whole velocity function of the key and it can give broader observation opportunity when its synchronized with motion capture data.(McPherson, 2013: 153).

EMG can be used to measure muscle activity. There is a more accurate type of EMG that needs needle insertion but it is painful so there is an ethical consideration to limit the collection of this kind of EMG data. Comparing EMG data gathered by 15 collage piano students and 15 non-musicians, it is found that during minimum muscle contractions, the pianists had a considerably greater firing rate, shorter duration, and amplitude of motor unit potentials than the non-musicians. When all the metrics were compared at different degrees of contraction, the pianists had a considerably greater firing rate only at 25% and 50% of voluntary muscle contraction, and a significantly larger amplitude at maximal contraction than the non-musicians. In pianists, the amplitude of maximal control contraction was higher than in controls. (Lai, et al., 2008: 574).

Some researches concentrate on body movements during playing. That kind of observation does not need to be under millimeter accurate so more affordable solutions can be preferred. Microsoft KINECT is a motion capture camera system. Hadjakos, defines the advantage of using KINECT as piano pedagogy systems and cost sensitive less accuracy required scientific examination in musician medicine and performance research. But for high accuracy, depth sensing fell behind the motion capture systems (Hadjakos, 2012: 5). Also, one Kinect found to be insufficient in order to evaluate torso movements of pianists during an experiment designed to expose Kinect's efficiency. (Beacon, et al., 2017: 66)

Force sensors can be installed under the keys. It is not easy because of the need for manipulation of structure of the keyboard. This way, forces applied to keys can be measured but in pressings not touching the keybed these sensors can not produce data. In the experiment of Parlitz, 5 players who had spend 4 hours on piano each day from their 6 and 10 and 5 amateur players who spend less than 1 hour on piano each day participated. Measurements done with a force sensor installed under the keys. The expert players relaxes his playing fingers immediately after each touch, whereas the amateur remains tense for much longer. Furthermore, the forces of the expert's non-playing fingers remain below the resolution of the measurement tool (2 N), whereas the amateur's first and second fingers reveal a massive waste of forces. Amateurs used substantially greater and longer force on the keys to achieve the same speed and loudness, resulting in higher mean pulses per touch. In both expert and amateur pianists, pulse and duration values increased as finger coordination demands increased (Parlitz et al., 1998: 1067). Patterson used force sensors to compare forces of small hands and large hands for different intervals. It is shown that as long as the interval gets bigger small hands having more difficulty to obtain the same force as the big hands can apply (Patterson, etal., 2011: 2).

According to Parlitz, experimental evaluation for rational assumptions of advanced piano playing that are motor programs optimized to achieve highest accuracy with minimum effort was not made until today (Parlitz et al., 1998: 1063). Rahman, underlines the necessity of measuring the dexterous finger movement of pianists while playing although it is very difficult to measure the finger bones, which are very complex (Rahman et al., 2011: 22). Beyond that complexity, each individual person has different hands. But these differences are all about ratios. The working structure of hands and bodies are mostly the same. Each hand has twenty seven bones and nineteen joints. But length and width of bones, tissues, muscles and flexibilities differs. But years of training give pianists ability to use their hands and bodies skillfully in order to reach more virtuosity (Tits et al., 2015: 102). Lee says that trained pianists, either with light and tapered fingers or with chubbier hands, both accomplish the desired tones (Lee, 2010: 172).

There are vast of measurement systems that can be used such as fMRI (functional magnetic resonance imaging), PET (positron emission tomography), NIRS (near infrared spectroscopy) etc. But most of these are hard to be used in an experimental setup including piano playing and far from being affordable.

4. DISCUSSION

Research on this area has been conducted principally by physicians, engineers but not so much with collaboration of advanced pianists. So the hypotheses and experimental designs that have emerged are mostly at the beginner level of piano playing. Also, as a result of specialization and communication deficiencies of pianists, the hypotheses used in experiments are mostly limited to struck or pressed touch, resistance in keybed, timing in repetition.

Also, in most of the works, the experiment uses two sets of piano players: expert players and novice players. The differences found between them during doing same tasks define the properties of better piano playing. But there is not a real definition of expert pianist. Most of the works uses experience as expertise, some of them adds diplomas taken and also some of them adds competition winners but most of them doesn’t ensure that their expert group are true reference of proficiency at specific skill in piano playing.

Even winning competitions are not a guaranteed way of becoming a concertist pianist. If being a concertist pianist is the highest degree in piano career, not all of them technically equally powerful. Even, the virtuosity was meant to be different in the nineteenth century than middle of the twentieth. Most of the most famous pianists are fall behind a sub set of pianists who are technically successors of the nineteenth century virtuosity. So the skills of expert pianists who participate in the experiments are not so trustful in order to test the hypotheses.

For measurements inside the piano, there comes another constraint: limited space to install sensors that are the tools to quantify piano playing. As a result, most of the experiments done with single keys, at most non consequent two keys. On the other hand, EMG, motion capture etc. systems interfere to the piano playing experience by installations to human body.

Although having quantitative researches on how to play piano, this approach couldn't be accepted by majority of piano education world. This situation has numbers of possible reasons. Under stress of highly competitive career, specialization in one direction became dominant and classical pianists gave up composing, improvising, tuning etc. They can approve the manifest of one shouldn't know how the car works in order to drive a car well enough. They are closed to follow the new findings in technology and the pedagogy so it is not easy for them to collaborate with scientists in quantitative researches in piano technique and pedagogy. Piano education is a tradition that mostly begins in childhood. The vast majority of pianists are the ones learned to play piano in their early ages thru mimicking their tutors and far from knowing analytically how they could learn their playing skills. They are only the ones that could survive in pianistic carrier and this situation is true for the virtuosos. As a consequence, most of the pianists cannot explain how they can accomplish their way of playing. Besides who studied piano pedagogy, most of the piano teachers are the ones that couldn't become a concert pianist so they don't have necessary information about being a pianist. So their students can not learn the desired knowledge. Also, most of the teachers find the amount of flourishing pianists and education adequate and rejects any methodical change all over. One reason of this may be performance teachers' feelings of disempower by their lack of familiarity with the content of the scientific findings. Parncutt says that performance teachers have tendency to refuse analytical approach for the sake of being an artist but grants them right because of the necessity of perform well is being non analytical somehow but then adds, analytical approach is still crucial for solving technical problems during preparing for stage (Parncutt, 2007:43). Besides these, keeping important knowledge as a secret is a known attitude in music tradition. For example, iconic virtuoso Paganini has said to be never played in rehearsals as he plays on concerts due to the possibility of someone figure out his tricks. Competition is merciless in music all over the history.

Whether they are teacher, philosopher or virtuoso pianist, their natural ability of playing piano can not be put in words easily. Language is one of the main factors that separate the human from animal kingdom but the language still far from being absolutely effective to explain the outer and inner world of human being. It is valid for piano playing also. The words like tension, relaxation, tightness etc. used in different meanings in different resources on piano pedagogy. (Wheatley-Brown, 2011: 49) Also, ¨press to the bottom ¨ and ¨legato¨ are two main directions in piano playing but they couldn't be described well enough. Idil Biret says that after she began to work with Nadia Boulanger, she learned the secret of piano playing is legato. (Xardel, 2006: 54).In fact legato is not

thought having a secret but a basic technic in piano playing that students in their first year accomplish. Also, the ¨press to the bottom¨ direction is used to be said by instructors strictly (Sen, 1999: 31) but in the touch categorizations of (Mimaki, 2010: 57) two of four types of touch don't make the key touch the keybed.

The machine called piano evolved in time but piano education couldn't grow cumulatively on previous declarations on piano technique whether they are scientific or not. The suggestions like finger technique and armweight technique are not sufficient for today. The change in piano is roughly towards louder and heavier. Hammers, touchweight, aftertouch, key dip, key sizes, thickness of strings and resonance of piano are increased throughout history (Mimaki, 2010: 8). Pianists who find chance to play with a nineteenth century piano can play Chopin and Liszt Etudes far more easily than today's pianos. Eighteenth century pianos are even easier to play. Neverthless they lack the sonority of the modern piano. Without all these factors, piano education would have been changed much more than it is than today. Quantitative research methods may close this gap with ease.

5. CONCLUSION

Piano is one of the most valuable music instruments. Its value is not based only their price but also the popularity of this instrument according to high sales rate and demand of taking piano lessons. The acceptance of piano and its technical evolution have been increasing since it's invention but methods of piano teaching couldn't evolve parallel to the technology. Although there are researches based on quantitate methods of today's technology, this approach couldn't find its value in piano education. On the other hand, the reasons of how famous virtuosos can play are still a mystery. Technology that enables us to gather and analyze data has big potential for solving this mystery.

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