Sound Enhancement of Musical Instruments by 'Playing them in': Fact or Fiction?

Gregor Weldert

Translation from German by Nigel Edwards & Tilmann Zwicker

Abstract:
Perceptual enhancement of the sound of musical instruments due to long-term playing has so far not been verified via controlled-condition experiments. Subjects were unable to make even a mere differentiation between much- and less-played instruments. Constant playing may lead to changes in the frequency characteristic, but such changes are not found in all studies. This review-article presents empirical findings concerning natural and artificial (mechanical) breaking-in. Different explanations for a possible breaking-in effect are discussed.

Many musicians - and instrument makers, as well - are convinced that musical instruments must first be 'played in' before reaching their full tonal qualities. This opinion is based on the assumption that the instrument itself or the wood would require a period of 'settling in' to develop a good tone. Also, lack of use would affect the tone negatively and, following such a phase, the tone would have to be reactivated by playing. Thus old and frequently played instruments would sound better. In principle, the factors providing a possible explanation for this phenomenon (singly or in combination) are as follows:

- *Familiarity*: not the instrument itself but the interaction between it and the musician has an effect. The player is able to overcome the weaknesses of the instrument over time and take better advantage of its strengths.
- *Selection:* top quality instruments are passed on, while lower quality ones are discarded at some point. Instruments do not sound better through frequent play; rather, they are more frequently played because their tone is good.
- *Maintenance*: musicians who are not satisfied with their instruments undertake alterations; with time improvements are achieved.
- *Aging:* the properties of wood or other materials (e.g. the felt on the hammer-heads in pianos) change over time, as does the overall system, e.g. time-dependent reduction in the inner tension of the completed instrument.
- *Continuous use:* vibrations occur through playing, causing changes in the wood or in the entire sound mechanism. Thus changes in tone are actually caused through playing.

Whereas the factors familiarity, selection and maintenance do imply an improvement in tone, with the factors aging and continuous use there is merely the assumption that changes occur. Whether or why these changes are inevitably felt to be positive is unclear.

Changes in the properties of wood

Changes through aging

A high elastic-modulus (thus greater sound velocity) as well as reduced damping are desirable tone-wood properties that change with aging. For example, the E-modulus for spruce increases, the effect being heightened through daylight. Damping, on the other hand, decreases under daylight and increases in the dark [1]. Furthermore, aged wood is less affected by humidity fluctuation, which adds mechanical and acoustical stability. These aging-dependent changes are partly reversible as the wood is subjected to higher humidity followed by dryness [2].

Yet aging is not a linear process. Spruce (but not cedar or maple) is affected by aging in terms of E-modulus, sound velocity, damping, rupture stress, hardness and sorption, but most of these property changes slow down after 25 to 30 years, or are even reversed, e.g. the residual stress in spruce decreases in the first 30 years, after which it increases again [3].

Changes through vibration

Various tests on wood samples show that the acoustic properties change in desirable fashion when they are continually subject to vibrations: the damping decreases [4,5,6,7] while the E-modulus increases. Also, these effects are dependent on the humidity [5,6,7,] or can even be reversed by humidity fluctuation [5]. Yet one experiment showed no significant changes in spruce, despite it being subjected to vibrations over a ten-week period [8].

To sum up, it can be said that vibrations and aging influence the properties of wood - in a desirable way. The E-modulus increases, while the damping decreases. And just as with changes from aging, it seems that vibration-dependent changes are reversible when subject to significant changes in humidity.

Possible explanations for the 'playing in' effect

Various physical explanations have been put forward for the playing-in effect, including resin crystallization or material fatigue in the wood or glue joints, which weakens the structure and allows greater movement of the vibrating elements [9]. One theory developed by wood technicians assumes that material fatigue results from an interruption in the cellulose molecule chains, as well as from the breaking up of the micro fibrils. Yet through movement (humidity-related swell and shrinkage) over a long period the molecular connections, broken up through stress, begin to reform. In this process, cellulose is – as the framework substance – the main component of wood yet it is also closely connected to lignin and hemi cellulose. These are mainly responsible for the movement in the wood. The explanation maintains that the damage to the cellular structure produces the 'playing-in' effect, and that the damage is caused by vibrations combined with the high stress suffered by the vibrating system (e.g. string tension). The movement of the wood, dependent on the humidity, on the other hand, reverses the 'playing-in' effect as the damaged structures are newly formed. This would explain why 'played-in' violins need to be reactivated after a long phase of not being used by increased playing, because in this phase the wood moves again [10].

A similar theory suggests that relaxation of drying stress is a plausible explanation of the 'playing in' effect [2]. As green timber dries, amorphous hydrophilic polymers, such as lignin and hemi cellulose, shrink whereas the crystalline cellulose remains unchanged. Crystalline cellulose is stiffer than the amorphous polymers, so their shrinkage is hindered by the cellulose, which leads to stress in the cell wall. This stress can be eliminated through aging or vibration, which leads to better acoustic properties.

Another theory [5] explains the playing-in effect through the slow displacing of water molecules away from areas under high strain to areas under low strain. A similar explanation assumes a molecular re-positioning [11]. Possibly the vibrations provide sufficient energy to break up the connections between the water molecules, which leads to less internal friction [6]. But it is unclear whether in the finished instrument the material parameters of the wood are subject to favourable change, or whether the composite materials (glue, linings etc.) are more likely to be influenced.

Testing for the 'playing in' effect

How can we verify whether a musical instrument improves by playing-in? There are basically two possible approaches: using actual acoustic measurements, or subjective evaluation by the player or listener. Although this sounds simple, it is anything but trivial. Acoustic measurements can only establish physical differences between the state before and after the playing-in, not whether this variance is at all perceived by musicians or listeners, let alone whether a perceived difference be evaluated as negative or positive. In addition, one cannot be sure whether the cause of a perceived difference is the result of playing-in or aging. A control group is essential. Subjective evaluations through test persons must take place in a double-blind situation in order to eliminate the influence of expectations, i.e. neither the test person nor the test supervisor should know whether the instrument under scrutiny has been played-in.

At a physical level, often the frequency curve is determined, and sometimes a complete modal analysis is made. An introduction to modal analysis can be found in Schleske [13]. Details of frequency-curve-measurement methods are recorded by Ziegenhals [14], who has researched the relationship between subjective and objective evaluation of musical instruments. His results show that characteristic tendencies can be derived from the frequency curve, tendencies that allow for the definition of a trend to the positive, and that also correlate with musicians' evaluations. This makes it possible to set up a ranking list of instruments of varying quality, which comes close to a corresponding musicians' appraisal. Yet there are cases where frequency-curve analysis shows little variance in instruments, although musicians perceive otherwise. Therefore evaluation by musicians actually playing the instruments must be strived for, especially considering that the quality of an instrument manifests itself only in the music generated by the player. In addition, with physical measurements, the test situation must be taken into account, because the musician, consciously or unconsciously, may considerably influence the acoustic properties of the instrument. A guitar, for example, sounds different when held by the player compared to when it is lying flat on the laboratory table.

Empirical tests for the playing-in effect made up to now

Natural long term playing-in

The Tokyo String Quartet gave a concert in 1994, performing on different sets of instruments. On the one hand, they played on their personally owned old (well played-in) Italian instruments; on the other hand they played on three different sets of instruments by contemporary violin makers, which they had never before rehearsed with. Afterwards, the audience was asked whether they could identify the set with the old Italian instruments, which indeed was the case. However, in this test the audience could actually see the instruments and the reaction of the musicians to these [15]. Later a recording of these performances was played to a dozen experienced musicians who were asked to make judgements. None of them could consistently differentiate between the old and the new instruments [16].

Further experiments investigating the supposed superior sound of old Italian violins compared to contemporary instruments gave similiar results. Twenty-one experienced players compared three old to three new instruments. The old ones were actually made by Stradivari and Guarneri whereas the new ones were top instruments in Stradivari and Guarneri style which were between several days and several years old. Under controlled double-blind conditions the players tended to prefer the new violins. Furthermore, the players were unable to distinguish between new and old instruments [17]. In a further investigation the judgement of experienced listeners was included. These listeners also tended to prefer the new instruments and were not able to distinguish consistently between new and old [18].

Hutchins [19] determined the frequency curve of several string instruments that were played for different periods of time. The level of many cavity resonances had increased, especially after consistent lengthy play and with resonances above 1 kHz. At the same time one instrument displayed a change in the frequency curve although it had been hardly ever played.

For a time-consuming experiment, researchers had let two identical violins be constructed from timber that had seasoned for 80 years; they then measured the frequency curves and conducted listening and playing tests with experienced musicians [20]. The frequency charcateristics were very similar and differed only in details, and in the subjective evaluations there was no significant difference between the violins, either. Then one violin was stored in a museum for three years, while the other was played intensively during this time by a professional musician. After three years both instruments were again tested, whereby the same results occurred: neither in the frequency curves nor in the double-blind listening and playing test were there significant differences between the violins. Seven years later, for the 10th anniversary of the project, both violins came together again. Unfortunately the tests then made were of an informal character without taking measurements. Nevertheless, all participants agreed that both instruments still sounded very similar. The museum's violin was felt to be somewhat more open, whereas the well-used instrument seemed a little darker in tone. But the played violin had older strings, while the museum's instrument had quite new strings [21].

Artificial playing-in with forced vibrations

Hutchins & Rodgers [10], using vibrations, were able to influence the difference between two selected resonances in violins. These were the cavity resonance A1 (ca. 450-490 Hz) and corpus resonance B1 (ca. 480-560 Hz). For the authors, this difference represents an essential quality indication in violins. They connected a loudspeaker to the violin bridge with a wooden stick and played music from a classical radio station for 1500 hours, so that the violin bridge vibrated. In the twelve vibrated violins the difference between A1 and B1 decreased by an average of 22 Hz with only the corpus resonance changing, not the cavity resonance. Two untreated violins served as a control. Their corpus resonance B1 decreased through humidity fluctuation only by 5 Hz. Musicians who played the violins before and after the vibration treatment perceived a lighter touch and a tone slightly less harsh after the treatment. The exact test condition, the number of players, and whether it was a blind test was not recorded by the authors. After several months of not being played, the B1 frequency of the test violins had increased again by an average 15 Hz.

Using a similar method, an experiment with three violins and a viola was carried out with 500 hours of vibration treatment via music from a radio station [16]. Immediately before and after the treatment the instruments were played by five competent musicians and recordings made for listening evaluations, so that a playing and listening evaluation could be made for each instrument. All participants were certain that changes had occurred and most found the change positive. A statistical evaluation was not carried out. It is unclear whether the test persons were aware of the vibration treatment and whether the experiment was conducted in blind or double-blind conditions.

Meanwhile commercial 'settling-in' machines are available. The effectiveness of such a machine, that makes the strings and thus, via the bridge, the whole guitar vibrate [9], was tested. Three pairs (same make, same model/year of make) of new guitars of different quality were tested. One of each pair was subjected to 348 hours of vibration; its twin served as a control. The frequency curves, as well as the subjective evaluations under double-blind conditions by nine experienced players, were measured before and after the treatment. No influence was perceived either in the frequency curves or in the subjective evaluations. The participants were unable to consistently distinguish which guitar had been treated and which had not. Based on these data, the authors suggest that marketing and suggestion, or the lack of control-group tests under double-blind conditions, are reasons for the frequently offered conception that vibration treatment has a definite effect. On the other hand, they point out that the energy introduced into the guitar by the vibrating machine is considerably less than that applied in normal play with a plectrum.

Considerably more energy (and thus a wider vibration amplitude) is generated by a procedure called *vibration damping reduction.* This method was developed and patented by Gerhard von Reumont [22]. Hereby an imbalanced motor is attached to the bridges of string or plucked instruments, which are then subject to strong vibrations. This is supposed to release tensions in the instruments. The effect of vibration damping reduction allegedly is based on relaxation processes trigered by overstressing i.e. over-stretching. ISupposedly, this leads to an improved, more balanced tone, a lighter touch and longer sustain. The measurement for the damping decrease, according to Reumont, is the measured decrease of the performance of the motor, because as the damping is reduced, less power is required. The Physikalisch Technische Bundesanstalt (PTB) in Braunschweig confirms in an evaluation the effectiveness of this method, based on frequency curve measurements. Zollner [23] points out that the method is unsuitable for solid body (electric) guitars, because their corpus should not vibrate. Also, he criticises that owing to measurement inaccuracies, the performance decrease of the motor is not a reliable gauge for the damping decrease. He also criticises the PTB measurement method because the power introduced into the instrument is not measured.

Nevertheless, since then further physical measurements taken from vibration damping reduced instruments have been published. These showed changes in the frequency curve in guitars and an increase in sustain times [24]. For two cellos, frequency curves and a complete modal spectrum were documented [12,25]. This showed an increase in the number of resonances, an increase eigenfrequencies of the modes, a general reduction in damping (yet a desirable increase in so-called radiation attenuation in the area of the lowest corpus vibration), as well as smaller level differences in the bending wave amplitudes.

At the same time, there are experiments which have disproved any substantial effect from this method. Meinel & Holz [26] have examined the effectiveness of the method, whereby they applied less energy than the inventor intended. They conclude that an improvement of the acoustic quality is certainly possible, but that improvement in all the instruments treated could not be conclusively verified. On the whole the effect on the frequency curve was negligible. Contrary to the results stated above [12,25] they found a frequency decrease (not an increase) in the resonances. Furthermore, there were level gains but also level losses and deepening resonance gaps. Also Leonhardt [27] found no lasting improvement in two tested violins. After six months of permanent vibration treatment he did find some aural and measurable changes, but these were not only positive but also negative. After a further three-year period of non-use, there were no improvements evident. He concludes that apparent advantages bring, at the same time, some disadvantages.

Summary and Conclusion

The available data on the objectively measurable effect through natural playing-in are inconsistent. One test showed hardly any influence on the frequency curve [20], whereas another showed an effect; but changes were also found in instruments that had seldom been played [19]. A subjectively felt improvement in tone could not be verified under controlled conditions [20]. It was not even possible to prove that much-played instruments could at all be distinguished from little-played instruments [16, 17, 18, 20]. While even without proof it seems plausible that instruments change over time or through playing, the question remains why this change should always considered to be positive?

Artificial playing-in through vibration treatment can produce measurable effects, but these cannot be proved in every case [9]. One possible explanation is the varying energy levels applied by the different methods. For the high-energy vibration damping method from von Reumont, mainly objectively measurable effects are presented [22,24,25]. Subjective evaluations have only been made informally [27], or exist only as individual-case, anecdotal descriptions by satisfied customers of the commercial suppliers of the method. Even if these evaluations are numerous, they remain exactly what they are: anecdotal individual -ase descriptions. Such customer opinions can theoretically be psychologically explained. Proof through controlled double-blind tests has not been made available. This does not mean that the method has no audible effect, but clear evidence is not yet available, and there is still no answer to the question whether the changes are felt to be mostly positive or not.

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