Vibrato correlation to sound quality in violin performance

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Abstract. Vibration is the most essential physical, and when applied as vibrato, artistic part of the music. When music is performed without vibrato, it is depleted to a level of a mere technical sound. The research is explaining why the vibrato is important and what is included in the term of artistic vibrato in various forms. The analysis is by comparative method of artistically passive and artistically active sound production and the respectful sound spectrum and dynamic properties in attempt to prove that passive sound production is inferior in content of overtones, dynamics and aesthetical qualities. Analyzing only the passive physical and technical properties of given instrumental sound and vibration is not sufficient, but it is necessary to consider the artistic performance and the vibrato as a factor and how the artistic vibrato reflects on the properties of sound. Samples from live recordings are submitted to a spectral and other analysis in order to establish empirical scientific connection between the physical and the artistic properties of the performance. Significant finding is the direction towards creating software that can verify and approve certain levels of artistic involvement during public performance, or educational practice of music.

1. Introduction
Why a skilfully vibrated sound and phrase on the violin captures your attention quickly and affects your mind and heart in a far more exciting way than the straight and not vibrated sound, or tone to be more specific, of a beginner violinist? Being deeply relational, musical instruments (especially string/bowed instruments) have acoustic properties that are exposed only while there is artistic interaction between them and the performer. How these interactions reflect on the psychological perception and the acoustical properties of the sound while using artistic vibrato is the main object of this research. Violin’s instrumental functionality and expression embeds and implies vibration in a variety of forms, functions and meanings that make it one of the best candidates for this analysis. The musical tone is already a vibration by itself with determined: frequency (pitch), power (dynamic), special overtone signature (color) and duration; the four properties in which tone differs from noise. Vibrato is the artistic part of it. When used as technical vibrato, it is generally to connect notes, show metrical significance and bring physical relaxation in playing. When it is used as artistic vibrato, it is part of the dynamic phrasing, culmination, brilliance and emotional expression during the performance. Vibrato brings natural properties to the tone based on the notion that bulk of modulated sounds and tones are produced by living things [1] and the motion of the Earth, while straight, mechanical and long term unmodulated tones and sounds are far less present in nature. We have all experienced the effect when in an airplane after a while we do not percept the sound of the engines although we know it is there,
like the noise of the city traffic sound pollution, or noise of the humming air conditioner, fluorescent lightbulb or a fan [2]. Psychologically, the constant unmodulated tone/ sound is perceived as of a mechanical origin and as such is likely to be cancelled by the brain, while the modulated one is perceived as from live origin and is some sort of communication [3]. In that sense, including the communication and recognizing it as part of the quality of the tone through vibrato would be the most significant finding that might change the perception of functionality of the acoustics in general. The artistic vibrato brings aesthetic and expressive properties that are in context of the style and performed musical piece. In the article “The Psychoacoustic secret of vibrato” by Martin Schleske [4] we read: Psychoacoustic experiments have shown that electronically manipulated vibrato that is solely frequency–modulated tends to be perceived as “synthetic” and “vulgar”, while pure amplitude modulation of the harmonics (with the frequency modulation artificially re–moved) is perceived as live and natural. It is clear the rejection point of such vibration, but it is not explained the second half of the equation, why the artistic vibration is perceived in a positive way as “live and natural”? The only explanation can be in the inner wiring of the brain and the system of alerting us in perceiving intent of communication.

In the realm of tempo artistic expressiveness is applied through rubato (a tempo–rhythm time sinusoid or tempo–rhythm fluctuation) with short tempo changes, while dynamic is a tool of artistic expression using the physical power of sound. Construction properties of the violin as an instrument, include basics elasticity of the wooden stick of the bow and the bow–hair, which make it to physically vibrate, as well as the sound plates of the violin and the strings that produce the sound, bringing exclusive characteristics to the sound that cannot be repeated except somewhat copied through digital sampling. In pursuit of objectivity, in the research were used six different instruments of a various class of make and sound properties, and only one bow from one maker, thus creating least possible variables in the used hardware that could affect the findings. The violin technique, all of the applied vibrato, phrasing, tempo–rhythm variables and all of the artistic attributes of vibration are in the full discretion of the performer. The analysis was restricted only to the non–vibrato and artistic vibrato sound samples and used was method by comparing artistically passive and artistically active sound production, their respectful sound spectrum and dynamic properties. The hypothesis was that the findings would prove that passive application of sound is far inferior in content of overtones, dynamics and aesthetical qualities. Therefore it was not sufficient to analyse only the passive physical and technical properties of given instrumental sound and vibration, but it was necessary to consider the artistic performance and the artistic vibrato as a factor. Among the other goals was to establish how the applied physic can help the performance process, and how in return the performance process should be part of the applied physics analysis of the sound, thus providing a connection between empirical sound analysis, artistic musical performance and the newly emerging discipline of psycho–acoustics.

2. Methods

Half of the samples chosen for analysis included performance with artistic vibrato. Samples from live recordings were presented to a spectral and other analysis in order to establish empirical scientific connection between the physical and the artistic properties of the performance. The recorded samples were obtained in a regular studio using the Voce Vista Video software from the Sygyt Software [5]. For measuring the frequency and the overtones of the violin was used standardized equipment by the ISO: NTi Sound Level Meter XL2 type 1, Earthworks M30 omnidirectional as a measurement microphone, XLR Cable with microphone stand and sound level meter type 1 where the data acquired was using the 1/3 octave frequency band for the Background Noise frequency data. The used microphone are also had flat frequency response and an omnidirectional polar pattern. The distance of the violin with the microphone was 1 meter apart and the tuning of the violins was 440 Hz as referenced in the ISO 16:1975. For production of the sound samples performed by Dr. Tomislav Dimov on the violin, were used the following makes of instruments: Gustav Lutschg (Switzerland), Otakar Spidlen (Czech), Mathias Heinicke (Bohemia), Eugenio Degani (Italy), Svetozar Bogdanovski (Macedonia) and Anonimus (Undetermined). A bow by maker Martin was used in–pair with all of
these instruments respectively. As musical samples that would involve artistic vibrato and active grade of engagement during the violinist performance, were used three famous excerpts from the musical literature. For sample 01 were used the first twenty one notes from “Tzigane” Rhapsody for Violin and Orchestra by Maurice Ravel. The properties of this sample are to perform in the lowest register on the violin with all of the pitches on the G string. Sample 02 involved the first seventeen notes from the beginning of the “Devill’s Trills” Sonata for Violin and Basso Continuo in g–minor by Giuseppe Tartini. This sample provided the data from the middle range of the violin equally divided between the third and fourth position on the violin and between the A and the D string. Sample 03 consisted of the first nineteen notes of the beginning of the violin solo part of the Concerto for Violin and Orchestra No. 4 in D–Major, K.218 by Wolfgang Amadeus Mozart. For appropriateness of the yielded material for spectral analysis, only the violin solo line was performed without accompaniment. Each of the samples was recorded without any vibrato (non–vibrato) and with artistic vibrato, thus producing a total of 36 samples. From each of the samples were used only notes that yielded clear and energetic vibrato, suitable for analysis. In each of the cases the choice fell to the last note of the sample, namely the twenty first note from the sample 01, the seventeenth note from the sample 02 and nineteenth note from the sample 03. It is noticeably consistent choice which points to probable increasingly artistically charged endings, inspired and intensified after playing the whole sample right before that.

3. Result and Discussions
The basic parameters of sound with and without vibrato from six different violins were analysed, their fundamental frequency and the yielded respective overtones. Below are the figures of fundamental frequency and the overtones of each of the violins with vibrato.

![Figure 1. In Anonimus sample 01_with vibrato.](image1)

![Figure 2. Bogdanovski sample 01_with vibrato.](image2)

![Figure 3. Spidlen sample 01_with vibrato.](image3)
The notes used as sound samples are the last vibrato notes of the each excerpt respectively. From the figures 1 to 6 we can conclude that each of the violins has the exactly same fundamental frequency and the same number of overtones. The sound level of each harmonic has a periodically fluctuating value due to the vibrato. The amount of the overtones was the same in the non–vibrato samples as seen in figure 7. There is a difference between the vibrato samples and the non–vibrato samples in sense that vibrato samples contain much more artefacts or noise, possibly created by the interference of the fluctuating fundamental and the overtones as seen in figures 6 and 7. This is the area that needs to be researched more in the future.
The biggest loss in decibels was observed between these two samples by Eugenio Degani, as shown above in figures 8 and 9. The non–vibrato sample had intensity of –24.5 decibels, while the vibrated showed –28.6 decibels.

The biggest gain in intensity was observed between the two samples, also by Eugenio Degani, as shown above in figures 10 and 11. The non–vibrato sample yielded –32.9 decibels while the dynamic intensity of the sample with vibrato was at –29.2 decibels.

Music is a type of communication largely brought by the effects of the artistic vibrato. The results of the research did not yield conclusive empirical results in the amount and extent of overtones. There are results in the field of the dynamic effects of the vibrato. The increased power in decibels of the
high range samples containing \textit{vibrato} versus the \textit{non-vibrato} samples proved the difference in to the effects of \textit{vibrato} regarding increased brilliance and suggestiveness of the performance. Dynamic increase in the sound projection was noticed in coincidence of the higher tension of the string and the intensifying dynamics of the tone due to the same releasing tension effect while using \textit{vibrato} in high position and in the high range on the violin. The \textit{vibrato} use contributed to less powerful sound during the performance in the lower range of the violin possibly coinciding with the releasing tension effects of the \textit{vibrato} and the lower frequency physical vibration of the violin plates.

4. \textbf{Conclusions}

In conclusion of this article it is important to mention that what made this project interesting is the fact that there has been no analogous research of the \textit{vibrato} in correlation to the sound quality. The role of the artefacts in the acoustical completion of the sound in artistic sense is especially interesting and unexplored. This and further exploration of the significance of the \textit{vibrato} should be in the realm of psychoacoustics with analysis of the scanned brain activity using newly developed methods. The findings clearly point in this direction and define the need to further develop psychoacoustics as a whole new discipline within the acoustics. Determination that tone with artistic \textit{vibrato} is more likely to be perceived as communication, is in contribution to a wider perception of the cross disciplinary function of the acoustics in the future. The significance of this research for the music industry and the education system is in setting the ground and the possibility of later creating software that can verify and approve certain levels of artistic involvement during public performances, or educational practices of music. It also adds the artistic dimension in to the acoustic analysis of the sound, in accordance of the most recent scientific trends of interdisciplinary fusion.

5. \textbf{References}

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