Proceedings of the Iowa Academy of Science

Volume 41 | Annual Issue Article 96

1934

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Recommended Citation

Small, Arnold M. (1934) "An Analysis of the Functional Timbre Variations of the Violin," *Proceedings of the Iowa Academy of Science, 41(1),* 263-264.
Available at: https://scholarworks.uni.edu/pias/vol41/iss1/96

AN ANALYSIS OF THE FUNCTIONAL TIMBRE VARIATIONS OF THE VIOLIN

ARNOLD M. SMALL

The research which has been previously directed toward the analysis of the timbre of the violin has not, to the best of my knowledge, ever objectively considered the dynamic character of the violin tone. A complete description of the timbre of the violin can never be attained until, in addition to the extant method of clang analysis, qualitative and quantitative statements are forthcoming regarding the timbre variations which are functionally based upon the tone-production factors inherent in violin-playing. These factors to which I refer are essentially: (1) bow direction; (2) point at which string is activated; (3) method of activation; (4) method of stopping the string; (5) choice of string to be used for production of a given frequency; (6) breadth of bow-hair surface in contact with the string; (7) intensity variations induced principally by variations in pressure exerted upon the string. This paper is confined to a discussion of the factor first mentioned above, namely, variation in timbre as a function of the change in direction of the bow.

The logical point of departure for this study is the open, or unstopped, string. The fundamental tone of the open string is accompanied by the maximum number of overtones ever found with any other fundamental produced by stopping the same string. Thus, optimum conditions for timbre variations here obtain.

Thus far, for this study, fifty oscillograms have been made of the open strings of my violin as I play them. The instrument is old Italian and was made by Zanoli in 1740. Each pair of one down and one up bow were played at three different levels of loudness — piano (minimum loudness), mezzo-forte (medium loud), and forte (loud). The electrical system and acoustical conditions of the recording room were identical for any one pair of down- and up-bow oscillograms. The standard procedure of harmonic analysis with the Henrici analyzer was then followed.

The results of the analyses show that for a given open string there are quite consistent variations in the relative intensities of certain partials between the tone as produced with a down-and with an up-bow. Furthermore, the amount of variation is dependent upon the loudness level. Let us consider somewhat in detail the results for the highest or E string, the frequency of which is 659 d.v. in the tempered scale with A at 440 d.v. The significant variations are found in the first, second, and sixth of a series of nine partials present. The percentage of the total intensity found in the first partial or fundamental, is less for the up bow than for the down, while for the second and sixth partials, it is greater. Moreover, as loudness increases the amount of variation in the fundamental decreases although in the second and sixth the opposite is true. For example, the ratios of down-bow to up-bow percentages of total intensity in the first and second partials are:

	First Partial	Second Partial
Played "piano"	1.73: 1.00	1.00: 1.13
Played "mezzoforte"	1.43: 1.00	1.00: 1.19
Played "forte"	1.29: 1.00	1.00: 1.28

Comparable statements may be made for the A and D strings. The variations occurring with the A string involve the first, second, and third of a series of twelve partials present. Here, however, the up-bow percentage is greater for both first and second partials and less for the third; increases in the loudness level enhance the first two and decrease the third. With the D string, the first, fifth, and seventh of a series of eleven partials are involved in the variations. The latter follow the same trends as those involved with the E string and in the same relative order.

Some exception must be noted in regard to the G, or lowest, string. The individual variations found here are neither as great nor as consistently in one direction as with the other three strings but the number of partials involved is twice as great as in any of the other instances. The acoustic spectrum of the G string shows a wider and more equal distribution of the total intensity than any of the other three strings; the distribution is through seventeen partials. The fundamental, being lower than the natural resonance region of the violin, is very weak. These conditions eliminate the possibility of any large variations in the first partial and increase the probability of variation in a large number of other partials. Further analyses must be utilized to permit a more complete understanding of the G string.

In conclusion, it can be said that the basis for timbre differences was found between a tone produced with a down-bow and again with an up-bow. The variations found were consistent, within the limits stated, both as to magnitude and direction. An interpretation of the perceptual concomitants of these variations awaits further psychophysical measurement in timbre perception.

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