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ON TROMBONE QUALITY

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Introduction

The quality of a musical instrument may be separated into two categories, subjective and objective. Subjective quality is a player's (or listener's) personal assessment of an instrument, and includes such factors as timbre, responsiveness and intonation. These factors may be rated quantitatively using Multidimensional Scaling (MDS) and Semantic Differential Scaling (SDS). The precise nature of these factors and details of how they may be quantified are given in reference (1). Objective quality is a general term used to denote the physical characteristics that are thought to govern the subjective quality of an instrument. From this definition it can be seen that objective quality cannot exist in isolation. Only when physical correlates to the many dimensions of subjective quality have been established will it be possible to describe an instrument as having a particular objective quality. The objective quality of a trombone depends ultimately on two physical characteristics; the geometry of the instrument, and its material composition. It is extremely difficult, however, to relate these physical characteristics directly to the dimensions of subjective quality. For this reason it is appropriate to investigate additional physical characteristics (e.g. acoustic impedance (2)) which are capable of being related to both subjective and objective quality, thereby establishing links between them.

The factors governing trombone quality have been studied by the author (3), in three parts:

(a) the creation of an original, improved impedance measurement system capable of providing absolute values for acoustic impedance (both modulus and phase);

(b) the establishment of the subjective dimensions of trombone quality, and the development of formal subjective assessment procedures which will enable players to quantify these dimensions;

(c) an examination of the extent to which the acoustic impedance of an instrument may be used to predict its subjective quality.

Parts (a) and (b) have been the subjects of two papers (2, 1), and it is the purpose of this paper to discuss part (c)

Two simple hypotheses are advanced which attempt to relate the subjective quality of a trombone to its impedance. They are based on the corollaries of a non-linear sound production mechanism given by Benade and Gans (4). For an instrument possessing a stable regime of oscillation :

(a) the overall amplitudes of the impedance maxima shall be high (hypothesis (a));

(b) the frequency locations of these maxima shall lie at closely harmonic intervals (hypothesis (b)).

Wogram's Sum Function (5) (which is calculated by summing the real part of the impedance at integral multiples of a fundamental frequency) is essentially a combination of hypotheses (a) and (b). If for a given instrument the peaks of the Sum Function are well defined and high in amplitude, then both of the corollaries given above are (at least partially) satisfied, and the instrument might reasonably be expected to possess stable regimes of oscillation. This proposal will, for convenience, be referred to as hypothesis (c).

Results and Discussion

Seven medium bore trombones have been assessed by two professional players using two Semantic Differential scales (1). One player appeared to relate quality (both in terms of timbre and ease of playing) to the degree of harmonicity of the impedance maxima, supporting hypothesis (b). When instruments of comparable harmonicity were presented to the second player, his assessment did not relate to any of the three hypotheses.

When considering objective measures of trombone quality it is helpful to consider the acoustical properties of straight tubes. The impedance of a tube 1.42 m long and radius 5.45 mm is given in reference (2). The overall amplitude level of the maxima is high and since the degree of the harmonicity of the maxima reasonably high, the peaks of the Sum Function for the tube are comparable with those of a trombone. However, the ease of playing and the timbre of a straight tube are non-existent and appalling respectively. In addition it is possible to "play" the tube at frequencies where the Sum Function is far from its maximum value. Thus the most unplayable "instrument" comes out best using the objective hypotheses: clearly these hypotheses must be revised in the light of such evidence.

Attention was turned to the envelope of the impedance curve. This is an appropriate feature of the curves to study since it forms the basis of the formant theory for timbre. In addition the spectrum of a trombone note is related to the magnitude of the impedance at integral values of the playing frequency, and thus the envelope of the impedance curve plays an important part in determining the spectrum of a note.

Accordingly the impedance curves were submitted to a Profile Factor Analysis (PFA), similar to the analysis used by Wedin and Goude (6). The data required are the values of the impedance maxima for the first twelve harmonics. This information is used to form a correlation matrix which is then reduced to a specific number of factors. The results showed that the first factor accounted for 93% of the variance, and hence by multiplying the factor loadings for each instrument by the raw data (the values of the impedance maxima), a Factor Profile may be obtained (see Figure 1). From Figure 1 it may be seen

that the Factor Profile may be thought to consist of three sloping lines joining maxima 2 to 5, 6 to 8 and 9 to 12 respectively. From a purely visual inspection of the impedance curves for the seven instruments it appears that the steepness of the slopes and the magnitude of the impedance at the point of intercept on the impedance axis correlate to some degree with subjective quality. However, there is as yet no evidence to suggest a causal link between the impedance envelope and subjective quality of an instrument.

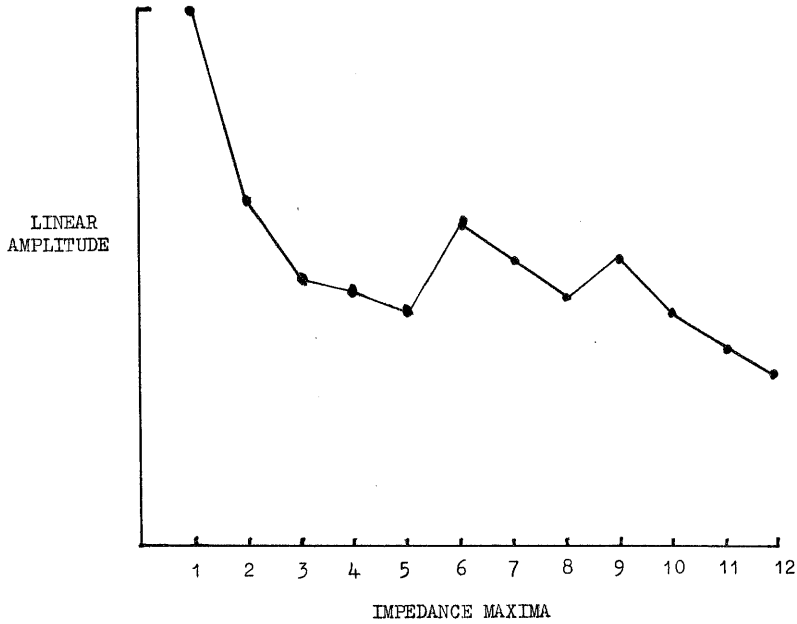

Figure 1 Factor Profile for the seven medium bore instruments

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