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THE CHARACTERISTICS OF THE PHENOMENON OF INITIATION (SOUND INTONATION) IN PLAYING THE WIND INSTRUMENTS*

ZYGMUNT PAWŁOWSKI, MAREK ŻÓŁTOWSKI

Department of Phoniatrics, Frederic Chopin Academy of Music
(00–368, Warsaw, ul. Okólnik 2)

It was found that the phenomenon of initiation in playing the wind instruments was characterized in particular by the value of the rise time of a sound (*RT*) and the value of the air flow during its duration. The values of the air volume (air output) and prephonation time (*TPP*) do not characterize significantly the phenomenon described.

Analysis was carried out on the physical properties related to initiation in playing the wind instruments. The instantaneous values of the air volume and flow rate were measured for the particular phases of playing.

30 musicians playing 7 groups of wind instruments were examined. The results of the investigations indicate the usefulness of the method applied in medical and didactic evaluation.

1. Introduction

The sound intonation is an essential phase of phonation. It follows from the authors' own observations and the literature communiques that the corrrect emission of the singers' voice depends on the correct phonation. In the case of instrumentalists, initiation is a counterpart of the sound intonation. There is no doubt that the quality of playing depends on the correct sound initiation.

The phenomenon is complex and affects in the further course of the play the value of the aerodynamic parameters, including the maximum play duration (*MPT*), the pressure before the instrument inlet (*SP*), the mean rate of flow through the lips and mouthpieces (*MFR*), the resistance of the lips and mouthpieces (*GR*), the expiration power (*EP*) and the work executed by the respiratory organ during the play (*S*). The problems have partly been investigated [6, 7] and are a further stage of studies in this field.

2. Intonation in singing

Both the world and Polish literature on the problem in question is scarce. The correct intonation determines the correct emission. On the other hand, it is known that hoarseness is the most important and sometimes the only symptom

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of the inefficiency of the larynx, in the form of functional perturbations or anatomical changes [1, 2, 4]. Because of this, it is justified to continue the clinical investigations of voice and music sound formation.

According to KOIKE, HIRANO, LEDEN [3], the intonation of human voice is characterized by 4 parameters: 1. the transient rise time (*RT*), 2. the air flow rate before the transient emerges (*RF*), 3. the air volume (air output) used up in the initial 200 ms of phonation (volume), 4. the time delay from the beginning of the expiration to the transient time (the prephonation time (*TPP*)).

On the basis of the parameter values obtained, the abovementioned authors distinguished 3 characteristic kinds of voice intonation.

The soft vocal attack (soft intonation) is characterized by a gradual increase in the transient amplitude, a smooth increase in the air flow rate (*FR*) and a low air volume (Volume).

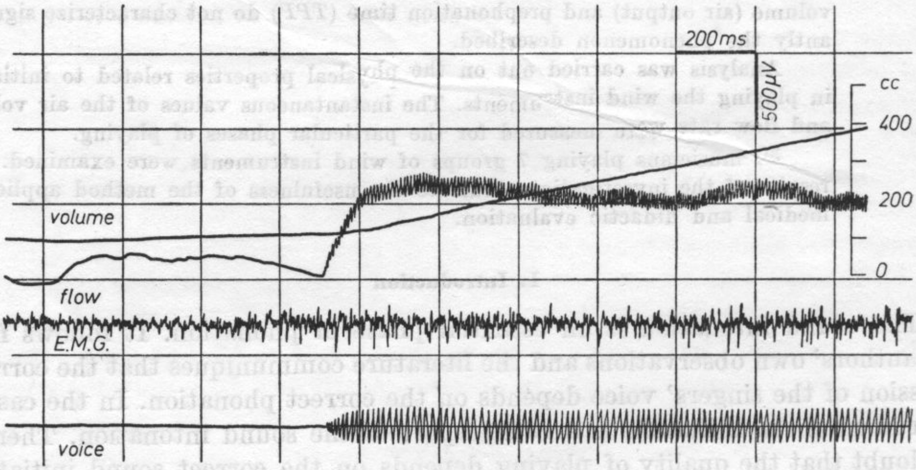


Fig. 1. Curves of changes in the volume (air output), air flow rate and sound level, according to KOIKE, HIRANO and LEDEN

Contrary to the soft intonation, the hard vocal attack (hard intonation used e.g. in staccato), is characterized by a rapid increase in the transient amplitude, a sharp increase in the air flow rate (*FR*) and a large increase in the air (Volume). A common feature of those two kinds of intonation is the fact that there is no air flow before the transient emerges.

The puffing vocal attack (the puffing intonation occuring most frequently in the pathologies of the larynx), shows a large value of the air flow rate (*FR*) before the transient begins, a distinct time delay from the beginning of the expiration to the time that the transient emerges (the prephonation time — *TPP*) and a very large volume of air. Changes in the transient amplitude envelope did not differ significantly from the soft and hard intonations.

It follows from these measurements that the values of the air volume and the prephonation time (*TPP*) are insignificant in evaluating the traditional voice intonation. In turn the values of the transient rise time (*RT*) and the air flow rate (*FR*) characterize significantly the phenomenon of voice intonation.

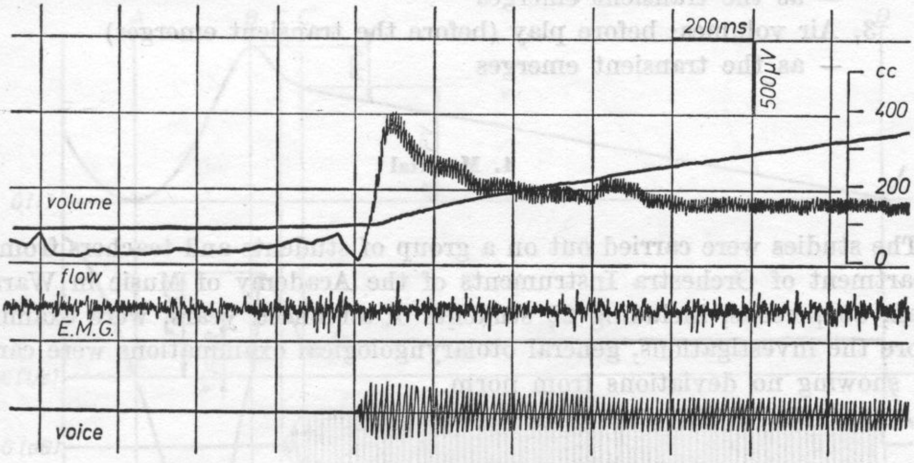


Fig. 2. Curves of changes in the volume, air flow rate and sound level, according to KOIKE, HIRANO and LEDEN

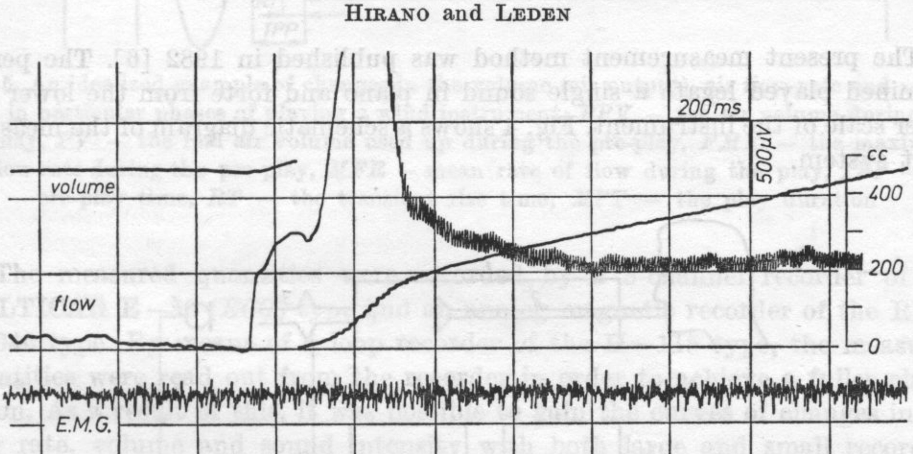


Fig. 3. Curves of changes in the volume, air flow rate and sound level, according to KOIKE, HIRANO and LEDEN

3. Assumptions and purpose of the investigations

In view of the limited literature on the physiological problems of playing the wind instruments [5–7], there is the need for these states to be complemented for the purposes of didactic certification and practice.

The aim of the investigations was to carry out an analysis of 3 parameters.
1. Pre-play time
   the transient duration
2. Flow: the maximum one before the transient emerges
   — as the transient emerges
3. Air volumes: before play (before the transient emerges)
   — as the transient emerges

4. Material

The studies were carried out on a group of students and teachers from the Department of Orchestra Instruments of the Academy of Music in Warsaw. In all, 30 persons, including 22 students of advanced years, were examined. Before the investigations, general otolaryngological examinations were carried out, showing no deviations from norm.

5. Method

The present measurement method was published in 1982 [6]. The person examined played legato a single sound in piano and forte from the lower and upper scale of the instrument. Fig. 4 shows a schematic diagram of the measurement system.

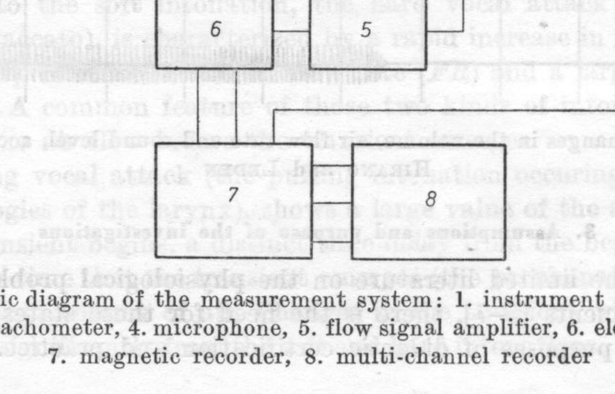


Fig. 4. A schematic diagram of the measurement system: 1. instrument encasing, 2. instrument, 3. pneumotachometer, 4. microphone, 5. flow signal amplifier, 6. electronic spirometer, 7. magnetic recorder, 8. multi-channel recorder

A full analysis of the phenomena occuring in particular phases of play requires a graphic representation of changes in the volume, flow rate and sound level as a function of time (Fig. 5).

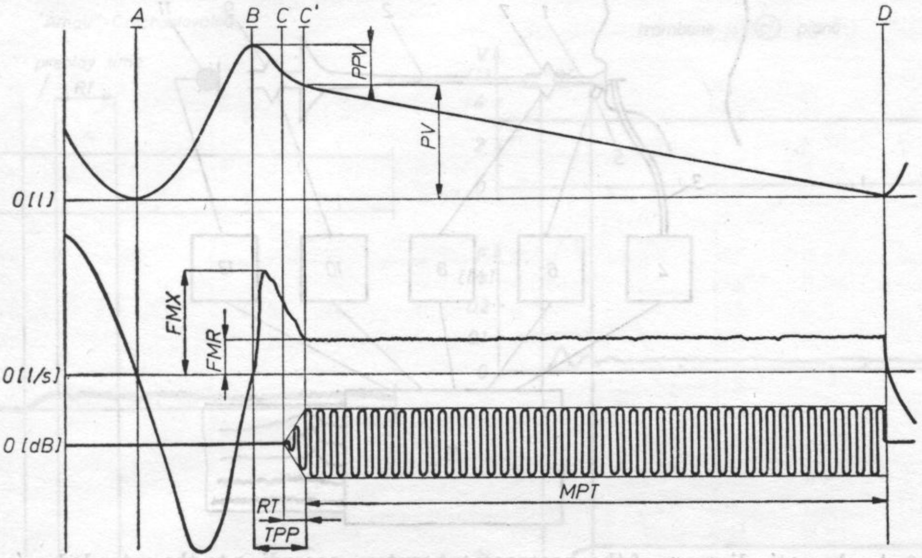


Fig. 5. An idealized example of changes in the volume (air output), air flow rate and sound level in particular phases of playing a wind instrument: *PPV* – the air volume during the pre-play, *PV* – the real air volume used up during the pre-play, *FMX* – the maximum air flow rate during the pre-play, *MFR* – mean rate of flow during the play, *TPP* – the pre-play time, *RT* – the transient rise time, *MPT* – the play duration

The measured quantities were recorded by a 3-channel recorder of the MULTICAR E–30 (*ECG*) type and an analog magnetic recorder of the RM–1040 type. By means of a loop recorder of the H–115 type, the measured quantities were read out from the recorder in order to achieve a fuller elaboration. As a result of this, it was possible to gain the curves of changes in the flow rate, volume and sound intensity with both large and small recording tape speeds.

The fragments of the play sequence of interest – here, the initiation reproduced at a high speed (50 cm/s), permitted the measured results to be achieved in a convenient form for further elaboration and interpretation. In considering the phenomena occuring in time intervals below 0.1 s (*TPP* and *RT*), some mutual displacements were found among the quantities recorded in time, depending on the situation of the microphone with respect to the instrument. In order to explain these displacements, extended measurements were carried out. They consisted in the recording of the flow rate at the inlet and outlet of an instrument and of the vibration of the mouthpiece part of the instrument and the sound level close to inlet of the instrument. The pressure inside the oral cavity was also recorded by the direct measurement method (Fig. 6).

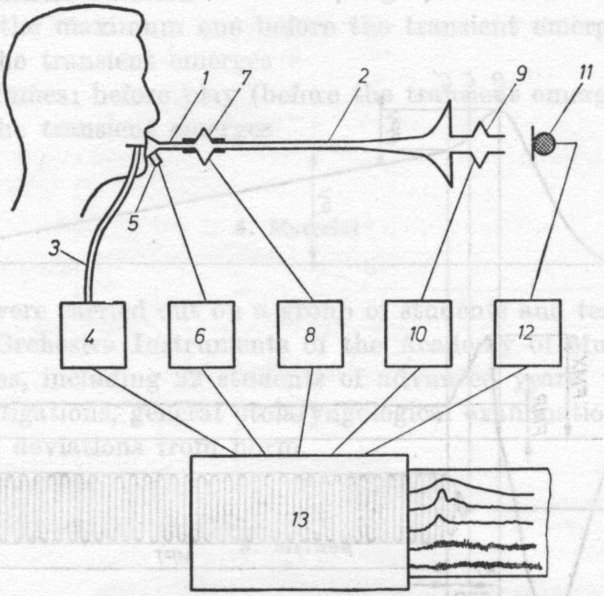
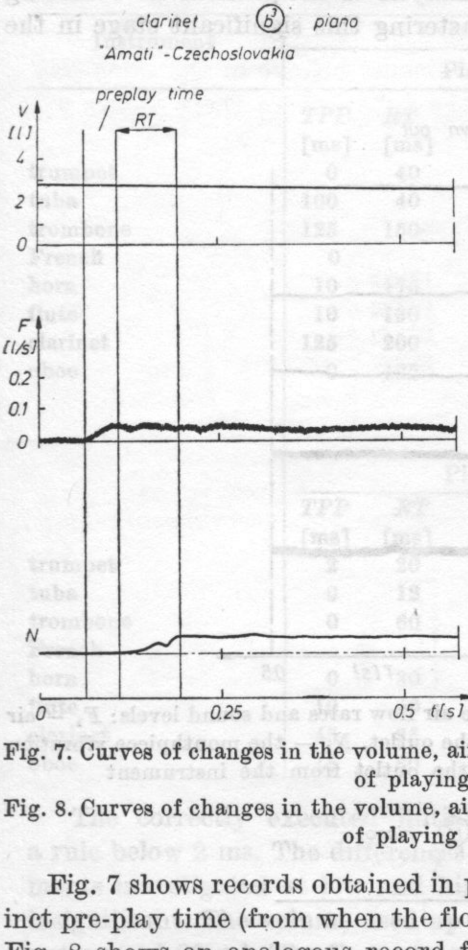


Fig. 6. A schematic diagram of the measurement system, according to the extended measurement method: 1. instrument mouthpiece, 2. instrument, 3. pressure gauge pipe, 4. pressure gauge, 5. vibration sensor, 6. vibration sensor amplifier, 7 and 9. pneumotachometers, 8 and 10. flow signal amplifiers, 11. microphone, 12. microphone amplifier, 13. multi-channel recorder

6. Results

The results were obtained from playing 7 wind instruments: trumpet, tuba, trombone, French horn, flute, clarinet and oboe. Fig. 7 shows the record of one the sounds played on the clarinet. Fig. 8. shows the corresponding record for the trombone. The successive curves represent changes in the following quantities: the volume V, the flow rate F and the sound level N in the initial stage of its formation.

In view of the large speed of the recording tape, the initiation phase is absent from the curves. The beginning of the changes in the particular quantities visualizes the first stage of the air flow and the accompanying sound formation. The diagram section shown represents about 0.5 s play. Over this interval, the air volume changes only slightly, about 0.025 l — the diagram of changes in the volume V shows no noticeable differences. The flow beginning is distinctly indicated by the course of changes in curve F and the accompanying sound effect N. The changes from the beginning of these curves to the moment when the curves become fixed at a given mean level are transient transitional states. The duration of these states contains in itself the pro-play time and the duration of the sound transient.



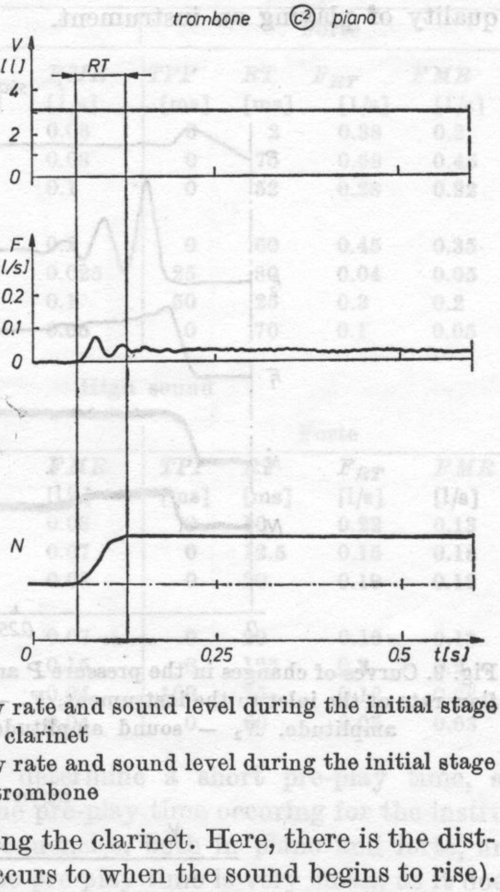


Fig. 7. Curves of changes in the volume, air flow rate and sound level during the initial stage of playing the clarinet

Fig. 8. Curves of changes in the volume, air flow rate and sound level during the initial stage of playing the trombone

Fig. 7 shows records obtained in playing the clarinet. Here, there is the distinct pre-play time (from when the flow occurs to when the sound begins to rise). Fig. 8 shows an analogous record for playing the trombone. In order to explain the doubts as to minimum time displacements in the curves of the the flow (F) and the sound level (N), additional studies were carried out following the extended methodology according to Fig. 6.

Fig. 9 shows records taking into account the flows and sound levels at the inlet and outlet of the instrument. Fig. 10 illustrates a distinctly bad sound initiation.

7. Discussion of results

The investigations and measurements carried out permit the characteristic quantities preceding the achievement of a sound at a given pitch and level to be determined for particular instruments.

The pre-play time and the transient duration, the flow occuring over these intervals, and the volume (air output) used up in these intervals, achieved by persons with sufficient music training, they can all provide the basis for characterizing the notion of initiation (Table 1). Analysis of the phenomena occurring in the initiation time can be helpful in mastering this significant stage in the quality of playing an instrument.

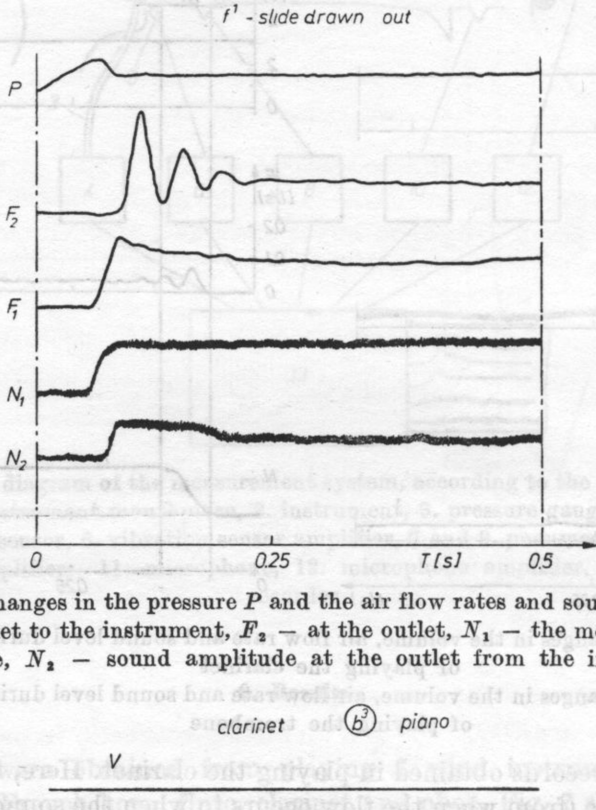


Fig. 9. Curves of changes in the pressure P and the air flow rates and sound levels: F_1 — air flow rate at the inlet to the instrument, F_2 — at the outlet, N_1 — the mouthpiece vibration amplitude, N_2 — sound amplitude at the outlet from the instrument

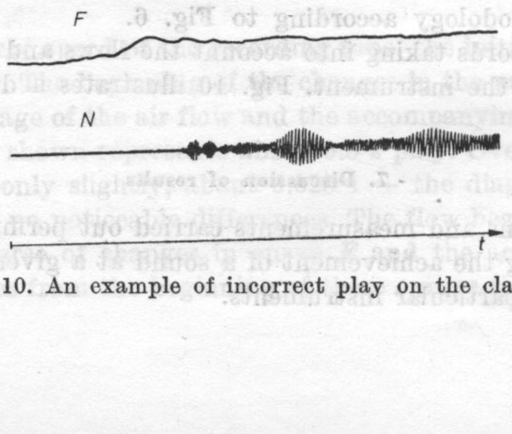


Fig. 10. An example of incorrect play on the clarinet

General observations on the pre-play times permit the following criteria of evaluation to be established.

Table 1

Instrument	Low sound							
	Piano				Forte			
	TPP [ms]	*RT* [ms]	F_{RT} [1/s]	*FMR* [1/s]	*TPP* [ms]	*RT* [ms]	F_{RT} [1/s]	*FMR* [1/s]
trumpet	0	40	0.11	0.06	0	2	0.38	0.2
tuba	100	40	0.15	0.08	0	75	0.68	0.45
trombone	125	150	0.13	0.1	0	52	0.28	0.22
French	0							
horn	10	175	0.3	0.2	0	60	0.45	0.35
flute	10	130	0.03	0.025	25	80	0.04	0.05
clarinet	125	200	0.16	0.1	50	25	0.3	0.2
oboe	0	125	0.07	0.05	0	70	0.1	0.05
	High sound							
	Piano				Forte			
	TPP [ms]	*RT* [ms]	F_{RT} [l/s]	*FMR* [l/s]	*TPP* [ms]	*RT* [ms]	F_{RT} [l/s]	*FMR* [l/s]
trumpet	2	20	0.13	0.08	0	10	0.22	0.13
tuba	0	12	0.04	0.07	0	12.5	0.15	0.18
trombone	0	60	0.07	0.03	0	20	0.19	0.12
French								
horn	0	30	0.09	0.07	0	20	0.16	0.13
flute	10	40	0.3	0.15	0	125	0.3	0.2
clarinet	45	85	0.05	0.04	100	75	0.12	0.08
oboe	15	60	0.08	0.04	0	60	0.05	0.03

The correctly executed initiations determine a short pre-play time, as a rule below 2 ms. The differences in the pre-play time occuring for the instruments investigated at low and high frequencies, both in piano and forte, are insignificant. The volume used up in the pre-play time is very small, as it does not exceed 20 ml. The flow accompanying these slight changes in volume and its character (with the instantaneous values exceeding largely the mean flow rate during the play) indicates a lack of coordination between the muscles of the respiratory organ and those of the articulatory one (the muscles of the lips and tongue).

In considering the subsequent stage of the play and the phenomena occurring in it, one can find that:

— The rise time *RT*, conceived as a time interval between a moment when a sound emerges and a time when it acquires given intensity, depends on afew factors.

The value of the *RT* for wood instruments when playing piano is greater than that for playing forte. Irrespective of this, the value of the *RT* changes depending on the pitch of sounds played. However, it is the sound intensity that determines the rise time *RT*. This time is between 50 and 500 ms. Changes in the sound dynamics correspond to those in the time *RT* at a ratio of 1 : 10, whereas during the play the pitch of the sounds played changes the *RT* over the limits of 1: 2.5.

The values of the time *RT* for brass instruments behave in the same way as those for wood instruments, except for the tuba, where these values are

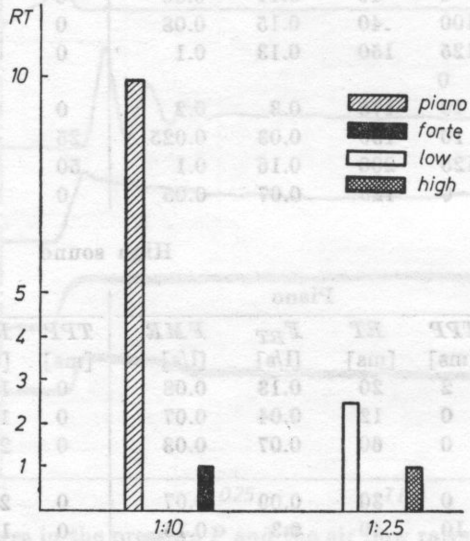


Fig. 11. An example of changes in the value ratios of the rise time (*RT*) depending on the sound intensity and pitch for wood and brass instruments

lower for playing in piano and greater in forte, both at low and high frequencies.

The volume air output used up over the rise time *RT* is small and insignificant for evaluating the inspiration, irrespective of the sound pitch and intensity for the instruments considered.

The air flows over the sound rise time are significant and concerned with:

1. brass (mouthpiece) instruments — in reference to the sound intensity and pitch. The value of the air flow rate is lower for playing in piano and greater in forte, occurring in the whole group of the instruments studied. However, the general values of the air flow rate is greater over the low sound range and lower over the high sound range.

2. in the case of wood (reed) instruments the air flow rate behaves in a way different from that in brass instruments — i.e. depending on intensity, the value of the flow increases slightly in forte, whereas, depending on the sound pitch, this value can even decrease, except for playing the flute, where the air flow rate increases.

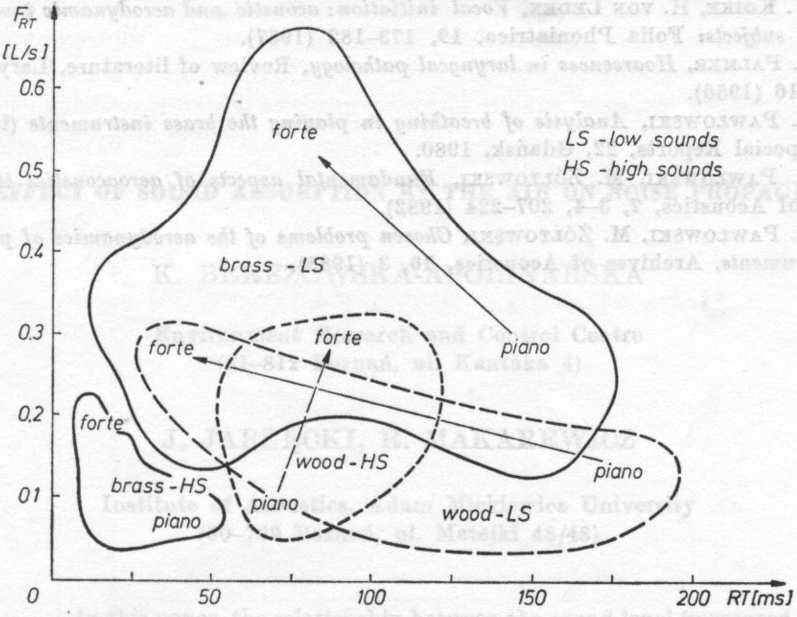


Fig. 12. Variability ranges of the air flow rates and rise times for the two groups of instruments

8. Conclusions

1. A significant feature is the value of the air flow rate, particularly over the sound rise time *RT*. Sounds played in forte are characterized by greater flow rate than that of sounds played in piano.

2. The air volume (air output) used up in the pre-play time and the rise time is small and does not characterize significantly the phenomenon of initiation.

3. The sound rise time *RT* decreases when playing in forte. As the pitch of the sounds played varies the value of the *RT* becomes slightly lower with their increasing pitch.

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