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PERCEPTION OF SOME INTONATIONAL DEVIATIONS IN MELODIES

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The aim of the experimental research was to determine sensitivity to intonational deviations in melodies. The following intervals were investigated: prime, minor second, major second, perfect, fourth, augmented fourth, diminished fifth and octave, as they appear in both tonal and atonal contexts. Subjects were music education students from Pedagogical University in Zielona Góra (Group One) and students from Chopin Academy of Music, Warsaw (Group Two). Each group consisted of 22 subjects. During each experimental trial the subjects listen to two versions of a short melody played on the piano. The second version of the melody was a transposition of the first one by a major second upwards. Moreover, in fifty per cent of the cases, the last tone of the second version was intonationally deviant either upwards or downwards. The subjects' task was to judge whether the last tone in the second version was an intonational deviant or not. Raw material from the research is presented in the form of psychometric functions. Tolerance zones of intonational deviations have been determined. The obtained results partially support the research findings on principles of tonal gravitation by other investigators, but some of the results are new.

1. Introduction

For a long time, theoreticians and musicologists have been busy arguing for the existence of pure musical systems in music practice. Therefore, even the slightest deviations from pure systems have been considered to be undesirable. The first experimental investigations in that area concerned the evaluation of purity of scales practised in the course of music instruction. DELEZENNE initiated such investigations in 1827 and continued them through many years that followed. He has established the Pythagorean scale as a standard pattern for intonational accuracy (ESBROECK&MONFORT, [2]). The view shared by Delezenne was later supported by other investigators such as RITTER (1861), CORNU and MERCADIER (1869), STEINER (1891), and JONQUIER (1898).

An experiment by GREENE [6] seems to have brought about some partial solutions as far as the problem of intonational purity is concerned. ESBROECK and MONFORT [2] published a study aimed at verifying the hypothesis of priority given to the Pythagorean scale. To a large extant, their findings supported the equally tempered system. In his theoretical considerations, HINDEMITH [8] also threw doubt upon the purity of a melody performed in a natural scale.

It was a research by GARBUZOV [5], however, which marked the starting point in establishing a new concept of intonational purity. Garbuzov maintained that the twelve-zone system was one in which vocal as well as instrumental pieces were performed. It also concerned the instruments tuned in the non-equally tempered system. He also held that the defined degree of tone system, theoretically established as a point on the frequency scale, determined the pitch zone of certain width from psychological point of view. Hence, many intonational variants of the same interval may function in accordance with the principle of intonational deviations of a given interval from the conventionally established standard pattern. Consequently, in recent research, the intonational deviations in intervals are considered in purely musical terms (FRANCÈS [3]; RAGS [10]; SAKHALTUYEVA [13, 14]; SHACKFORD [15]; CUDDY [1]; FYK [4]). Despite the above, the idea of a very close interrelationship between perfect intonation and numerical parameters seems still to prevail.

Most of the recent research on the musical intonation concerned vocal music and the music performed on instruments tuned in a non-fixed way. The perception of intonational deviations in melodies with respect to sounds used in common music practice is, however, the problem that is by no means solved (FRANCÈS [3]; FYK [4]; HARAJDA & FYK [7]). Therefore, there is a pressing need to bridge some gaps in that field. The aim of the present study was to investigate perception of intonational deviations of different magnitudes from the following intervals: prime (1), minor second (m2), major second (M2), perfect fourth (4), augmented fourth (4#), diminished fifth (5b), and octave (8). Short tonal and atonal melodies composed specifically for this research, were performed on the piano, and recorder on tape.

The intention of this research was to determine the intonation tolerance zones, i.e., to establish the permissible size of pitch deviations that can still be tolerated.

2. Method and Data Representation

Subjects were 22 students of music education from Pedagogical University in Zielona Góra (Group One) and 22 music students from Chopin Academy of Music in Warsaw (Group Two). To study the impact of musical education experience on the perception and tolerance of intonation deviations, the subjects selected for this experiment were divided into two groups. The first group members had 7–9 years of musical training and the second one — 14 years.

The test material was composed of 10 series comprising tonal and atonal melodies. Intervals under investigation appeared in two or three different melodic contexts and ended the melodies. The use of both tonal and atonal contexts allowed us to investigate the possible impact of tonality and movement direction of the interval on the perceptual tendencies. Each series of trials contained 20 pairs of a two-bar-long melody performed on the piano. The first tune in the pair was the standard melody whilst the other one was its transposition by a major second upwards. In the transposed melody the last tone was intonationally deviant in fifty per cent of the cases. The values for the intonational deviations, both upwards and downwards, were: 5, 10, 15, 25, and 50 cents where 1 octave = 1200 cents. The transposition of the second melody was introduced in order to eliminate the possibility of pitch comparisons of the last tones in two melodies rather than comparing the sizes of actual intervals. The order of individual pairs was randomized. The musical material of the test is presented in Fig. 1.

Fig. 1. Musical material of the test.
I, II. . . VIII — degrees of a major scale, A — interval in atonal context. In frames — interval intonationally deviant

Recorded test material was reproduced through a loudspeaker. The subjects listened to the test in groups of 11 persons each. The subjects were asked to state whether the intonation of the last tone in the transposed melody was the same as in the standard melody. Raw test results were combined in a form of psychometric functions. The psychometric graphs illustrated relationships between the relative frequency of "I can hear a difference" responses and magnitude and direction of intonational deviations from given intervals. To present those two interrelationships quantitatively, the notion of the thresholds of intonational deviation perception of standard interval was introduced. The standard interval corresponded to the size of the given interval in the equally-tempered system. The thresholds were determined in the following way. The segment corresponding to the percentage of correct responses when no intonational deviation occurred was divided into two halves. From the division point, perpendicular lines were drawn in both directions to the points of intersection with psychometric curves. The projection of the points of intersection onto the abscissa pointed out the values of intonational deviation thresholds of the standard interval for intonational deviations upwards and downwards. The thresholds of intonational deviation perception represent the listener's ability to recognize the pitch change in the second tone of the interval.

In order to analyze results in the graphic form, it was necessary to introduce the notion of intonational deviation tolerance of a standard interval. The flatter the course of the psychometric curve at zero point, i.e. at no deviation point, the greater the intonational deviation tolerance. The above described intonation deviation thresholds mark out the boundries for the tolerance zone of intonational deviation of the standard interval called thereafter the zone of intonational deviation tolerance; in short, the intonation tolerance zone.

3. Results

For a given interval, each person from Group One (music education students) gave 5 answers to any out of ten intonational deviations of the interval under investigation and 50 answers to the melodic pairs of the same intonation. For each interval at any measurement point, the total amount of responses was 110 and 1100 in Group One. In Group Two, fifteen subjects gave 3 answers to any of ten intonational deviations of interval under investigation and 30 answers to the melodic pairs of the same intonation. Two subjects gave 2 and 20 answers; and five subjects — 1 and 10 answers, respectively. For each interval at any measurement point, the total amount of responses in Group Two was 54 and 540, respectively.

As an illustration, psychometric curves for an octave interval (8, VIII → I, major scale) are shown in Fig. 2. Intonational deviations in cents are marked on the abscissa whereas the percentage of "I can hear a difference" responses is shown on the ordinate. For the intonationally deviant interval the percentage of "I can hear a difference" responses corresponds to the percentage of intonational deviation recognition.

For the octave, the percentage of false alarms in both groups was different: twelve per cent in Group One and forty-five per cent in Group Two. False alarms are understood as responses in which the subjects stated that they heard intonational deviations where there were none.

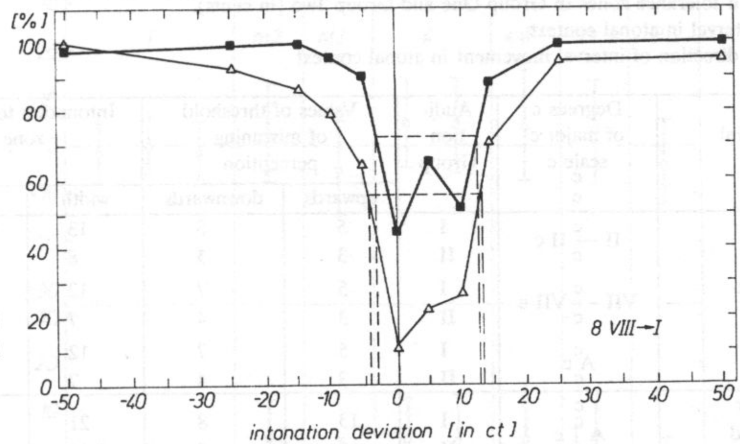

Fig. 2. Percentage of correct recognition of standard interval-octave (8, VIII → I) as a function of intonational deviation of the very interval in melody.
△ Group One, ■ Group Two

In both groups of subjects, the decrease in the octave size is evident, but in disagreement with the movement direction of the interval. The effect may be due to much stronger influence of the upper tonic than the lower one.

Table 1 shows the values of the threshold of intonational deviation perception for the intervals under consideration as well as the width and centre of intonation tolerance zones for Group One and Group Two. The widths of tolerance zones for the intervals under investigation are presented in Fig. 3 for both Group One (top) and Group Two (bottom). The zero value corresponds to the frequency of the second tone of the standard interval (440 Hz). The centres of the tolerance are marked by small circles. When the zone centre moves above the zero point, the interval size is inclined to increase. Conversely, when the zone centre falls below the zero point, the interval size tends to decrease. The shift of the central values as regards the zero level points to the direction of those tendencies.

4. Discussion

On the basis of the results presented in Table 1 it can be seen that the widths of intonation tolerance zone for the given intervals were similar for two groups of subjects. The value of correlation coefficient, $r = .94$ and $p = .999$, supports the thesis of the similarity of the results. In the case of centres of intonation tolerance zone the value of correlation coefficient was even higher, $r = .99$ and $p = 1$.

The subjects were the most sensitive to intonational deviations of prime and octave interval. Intonation tolerance zones for those intervals range from 12 to 17 cents in Group One and from 7 to 16 cents in Group Two. The widest tolerance zones have been obtained for augmented fourth, 23 cents in Group One and 22 cents in Group Two.

For prime, in both groups, there was a tendency to recognize intonation deviations of the second tone shifting down. As for minor second in an atonal context, there was

Table 1. Threshold values of intonational deviation perception. Width and centre of intonational deviation tolerance zones in Group One and Group Two (in cents).
A — interval in atonal context
↓, ↑ — direction of interval movement in atonal context

Interval	Degrees c of major c scale c	Audition Group	Values of threshold of mistuning perception		Intonation tolerance zone	
			upwards	downwards	width	centre
Prime /1/	II → II c	I	5	8	13	−1.5
		II	3	5	8	−1.0
	VII → VII c	I	5	7	12	−1.0
		II	3	4	7	−0.5
	A c	I	5	7	12	−1.0
		II	3	4	7	−0.5
Minor second /m2/	A ↓ c	I	13	8	21	102.5
		II	12	4	16	104.0
Major second /M2/	A ↓ c	I	15	5	20	195.0
		II	15	4	19	194.5
Perfect fourth /4/	V → VIII c	I	14	4	18	505.0
		II	12	4	16	504.0
	A ↑ c	I	14	6	20	504.0
		II	13	7	20	503.0
Augmented fourth /4#/	IV → VII c	I	15	8	23	603.5
		II	15	7	22	604.0
Diminished fifth /5♭/	VII → IV c	I	14	8	22	603.0
		II	13	4	17	604.5
Octave /8/	VIII → I c	I	13	4	17	1195.5
		II	13	3	16	1195.0

a tendency to enlarge the interval size in agreement with the movement direction of the interval. The perception tendency for major second in atonal context was to decrease the size of the interval, which was in disagreement with the movement direction of the interval.

For perfect fourth, in both Group One and Group Two, there was a tendency to enlarge the interval size in accordance with the movement direction of that interval in both melodic contexts. As there were no data on the perception tendencies for the forth in the opposite direction, i.e. falling down, it was impossible to determine whether this tendency was caused by the movement direction of that interval only or not.

In augmented fourth, the second tone of that interval was commonly regarded as leading to the resolution. The result was the tendency to enlarge the interval size. Such perception tendencies were caused by tonal gravitation of the second tone in augmented fourth. As for diminished fifth, the presented data did not confirm the impact of tonal gravitation on decreasing the interval size. To the contrary, the tolerance to intonational

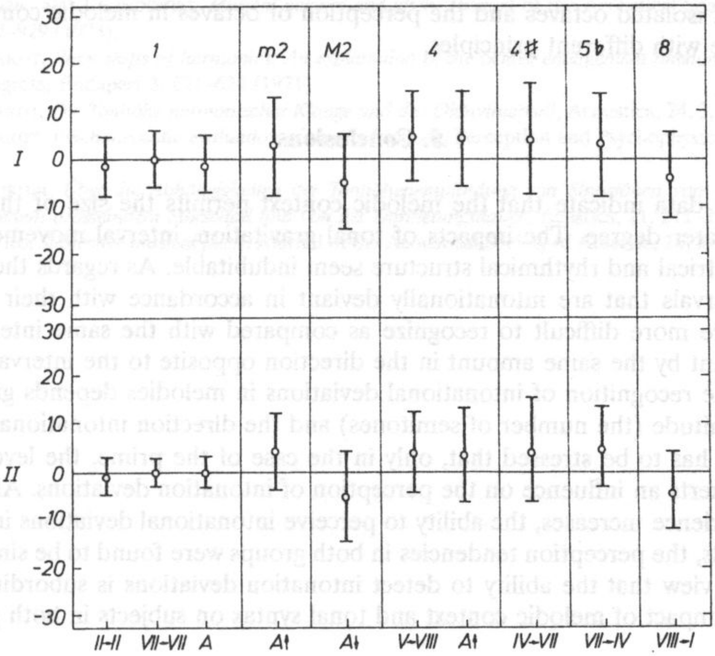

Fig. 3. Width of intonational deviation tolerance zones of the interval under investigation. I, II. . VIII — degrees of major scale, *A* — interval in atonal context, ↓; ↑ — direction of interval movement in atonal context, ∘ — zone centres

deviations in the upward direction was greater. The latter finding is in agreement with the tendency to enlarge the interval size in diminished fifth, when the interval movement is in the upward direction.

The findings of this study that the octave tended to decrease in size did not provide a support for the previous hypothesis on the octave enlargement phenomenon raised by TERHARDT [17, 18, 19]. According to Terhardt, the phenomenon of octave enlargement is due to mutual interrelationship between the first and the second tone of the interval. Those two harmonic tones are assumed to affect each other. Kept in the memory, the size of the enlarged octave is thought to be reproduced afterwards in melodic sequences. Terhardt also maintains that the octave enlargement in pure tones is greater as compared with the same phenomenon in complex tones.

The tendency for the melodic octaves to be perceived as the physical interval smaller than 1 : 2 was also reported by other authors (WARD [21]; WALLISER [20]; SUNDBERG & LINDQVIST [16]; RAKOWSKI [11]; MIŚKIEWICZ [9]; RAKOWSKI & MIŚKIEWICZ [12]). All these studies were carried out on pure tones or harmonic sounds.

When discussing the discrepancy between the results of this research and the results obtained by the other authors, one must be aware of entirely different conditions in which those investigations were carried out. The present study was focused on the perception of octaves in melodic context while other researchers limited their investigations to isolated octaves only. It is noteworthy that the phenomenon of enlarged octaves emerged from the research on isolated octaves. The present research findings seem to suggest that the perception of isolated octaves and the perception of octaves in melodic context function in accordance with different principles.

5. Conclusions

Presented data indicate that the melodic context permits the size of the interval to vary to a greater degree. The impacts of tonal gravitation, interval movement direction as well as metrical and rhythmical structure seem indubitable. As regards the atonal context, the intervals that are intonationally deviant in accordance with their direction of movement are more difficult to recognize as compared with the same intervals intonationally deviant by the same amount in the direction opposite to the interval movement. Moreover, the recognition of intonational deviations in melodies depends greatly on the interval magnitude (the number of semitones) and the direction intonational deviation.

In sum it has to be stressed that, only in the case of the prime, the level of musical experience exerts an influence on the perception of intonation deviations. As the level of musical experience increases, the ability to perceive intonational deviations improves. For other intervals, the perception tendencies in both groups were found to be similar and this supports the view that the ability to detect intonation deviations is subordinated mainly to the same impact of melodic context and tonal syntax on subjects in both groups.

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