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Microtones

The word *tone* as used in music theory, has two meanings: firstly, a single tone as opposed to the chord, and secondly in the sense of a tone step. When one speaks of whole tones, semitones or quarter-tones then it is the second meaning of the word that is being referred to. The term *microtone* also refers to the second meaning and designates as a generic term all steps on the pitch scale which are smaller than a half tone step.

From ancient times, many oriental music cultures have made use of finer tone steps than those which our traditional 12-semitone system offers. Already in the ancient world, microtones were described in rational proportions in the so-called enharmonic mode by Greek music theorists. In the 2nd century AD, Ptolemy wrote three important books about the ancient practice and theory of music; in his second book he pointed out that the whole tone must be subdivided into twelve microsteps, hence the octave into 72 microsteps in order to obtain all the pitch steps that were practically being used.

In the Christian music of the early Middle Ages the enharmonic mode was dismissed in favour of the diatonic genus. The reason for this was that the Christians remoulded the ancient ethical doctrines.

In the course of the development of polyphony the repertoire of the tone steps of the medieval hexachord system was insufficient and was continually expanded by placing the accidental. These chromatic changes did not mean a transition into another modus, instead a tone colouring – a “brightening” or a “dimming” – which served the intensification and weakening, respectively, of the melodic tendency progress. The use of tones which were not in accord with this system were called “musica falsa” or “musica ficta” by many music theorists. The development could not be stopped in polyphonic music if one wanted to place pure consonances over or under an existing voice.

During the Renaissance period there was a general consciousness that there had been an ancient Greek tetrachord division and many sophisticated systems were developed, not only to realize perfect fifths but also perfect thirds on keyed instruments.

Nicola Vicentino (1511–1576) subdivided around 1555 the whole tone into five microtones each with about 40 cents and developed with his "Archicembalo" and the "Arciorgano" instruments with 31 keys per octave.

This attempt, however, was only an approach to the ideal fifth (3:2) and the third proportion (5:4). An absolutely exact realization is impossible because octaves, fifths and thirds do not exactly go into each other, because the proportions rely on the prime numbers 2, 3 and 5, respectively, whose products and powers do not concur.

A century after Vicentino, 1675, Nikolaus Mercator (1620–1687) developed a 53-step system. This system is superior to all other subdivisions of the octave in one respect: his steps cover, with great accuracy, the values of the Pythagorean scale based on the fifth proportion (3:2) as well as those of the Didymic scale, in which the perfect major third with the proportion (5:4) is included.

While twelve perfect fifths put on top of each other exceed seven octaves by the Pythagorean comma (23.46 cents), 53 fifths are only 3.62 cents bigger than 31 octaves. If you put a major third on eight fifths (in the circle of fifths from C to G sharp) the five octaves are exceeded just by the so-called schism (1.95 cents); this means that you can fit into the system the major thirds with an accuracy which lies far below the discrimination of the ear (tone identity). The 53-step system combines octaves, fifths and thirds much better than our twelve step one. Its disadvantage is that it is very unwieldy.

In the second half of the 19th century, for many composers, the chromaticism which they could put to use in the 12-step tempered system was insufficient; they required a finer distinction and made experiments with quartertones. These can be easily formed by singers, string and wind instrument, but cannot be controlled exactly. In order to fulfill these requirements, the first quarter-tone piano was built in Moscow in 1864. This was followed by the Behrens-Senegalden model.

Apart from this simple subdivision of the semitone, there were attempts to subdivide the octave organically into such fine steps that they could represent exactly defined proportions. While Carl Eitz (1848–1924) in constructing his "Eitz Harmonium" used again the 53-step system, the Dutchman Adriaan Daniel Fokker, as Vicentino before him, decided in the 20th century to use the 31-step system.

Since the end of the 19th century, many composers have made use of microtones in their compositions and have tried to explore the limits of audibility

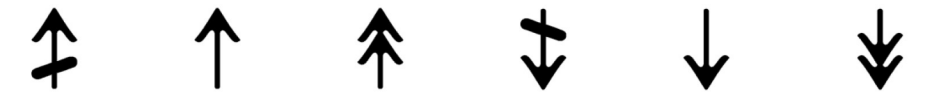
and controllability of a fine step chromaticism. They reached different stages. While the Mexican composer Julián Carrillo (1875–1965) demanded microtones down to a level of 1/16-tone (12.5 cents), others were satisfied with quarter-tones or sixth tones, amongst others Charles Ives (1874–1954), Béla Bartók (1881–1945), Alois Hába (1893–1973), and Ivan Wyschnegradsky (1893–1979).

The composer Wyschnegradsky introduced in 1916 the term "Ultrachromaticism" for the fine step melody shape which uses microtones. Apart from him, Georgy Rimsky-Korsakov (1901–1965), the grandson of the famous composer, and Arseny Avraamov (1886–1944) devoted themselves to research into microintervals during the 1920s. Their work led, in the 1960s, to the construction of a synthesizer by Evgeny Murzin (1914–1970) with a 72-step subdivision of the octave. The synthesizer can be seen at the Scriabin Museum in Moscow.

Since 1970 at the Mozarteum in Salzburg, the 72-step system – as proposed by Ptolemy – has been tested both in theory and practice: Maedel and Richter Herf 1977, Maedel 1983, Franz Richter Herf with his opera *Odysseus* and and numerous other compositions with microtones (Ekmelic Music), vinyl records DIESIS.

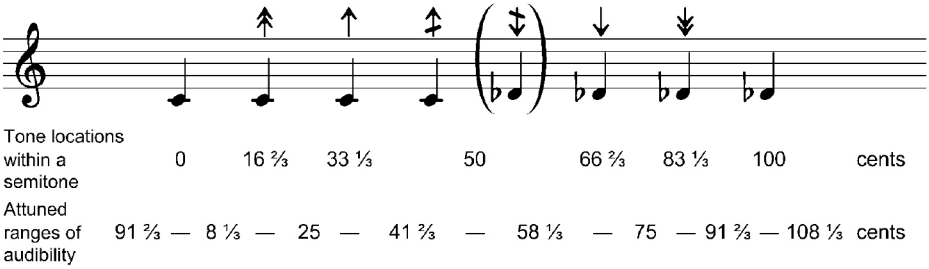
The collaborators of the Institute for Basic Musical Research at the Mozarteum settled on the 72-step system for the following reasons:

1. The size of the tone steps within the 72-step system (16.67 cents) is estimated in such a way that the pitch distinction is easy to recognize with long sustained tones (the limit of pitch discrimination under this condition lies between 5 and 8 cents), on the other hand, in dynamic music, this is near the medium limit of the discrimination for pitches.
2. The number 72 is a multiple of 12. Therefore the 72-step system comprises all the steps of the equal tempered semitone system and moreover, offers a finer gradation of the tempered semitone steps in six micro-step, respectively.
3. In this system, the most essential natural tones (overtones, partial tones) are approximated to ± 5 cents, whereas the limit of pitch discrimination in dynamic music remains below this level (sound identity).
4. The microtone steps can be notated with only three additional signs to the conventional notation.

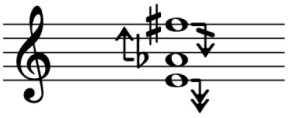


1/4-tone raised | *1/6-tone raised* | *1/12-ton raised* | *1/4-tone lowered* | *1/6-tone lowered* | *1/12-tone lowered*

The arrows are always placed above the notes and apply to the respective measure, just like the accidentals. A diagonal slash cancels them. The cent values for the six tone locations and their attuned ranges of audibility are specified below:



With chords, bent arrows show which tones are to be raised and lowered, respectively:



10:13:22

The arrows hardly complicate the legibility of the score; practice has shown that the musicians are acquainted with the additional signs in a minimum of time. With the exception of keyed instruments, all instruments are able to play microtones; the best are of course the strings and, among the brass instruments, the trombone. The woodwind instruments can reach all the microtones demanded – partly by employing new fingering positions not used till now, partly by changing the lip tension. An electronic keyed instrument with 72 steps per octave was built in Salzburg in 1974.

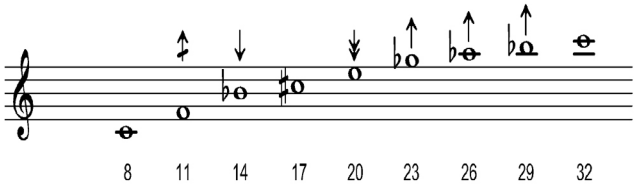
In order to make appropriate use of microtones in polyphonic compositions, the quality of the harmony (sonance) has to be considered because music

which does not take harmony into consideration, does not correspond to the character of occidental polyphony. According to the disposition of our sense of hearing, we notice the ratios of the frequencies when more tones sound simultaneously. These ratios are always expressed by integral proportions. In practice, within the 72-step system, all proportions up to 105 can be used, since the proportion 105 : 104 is the smallest step in the system. The level at which a chord merges depends on the selection of single tones and their grouping.

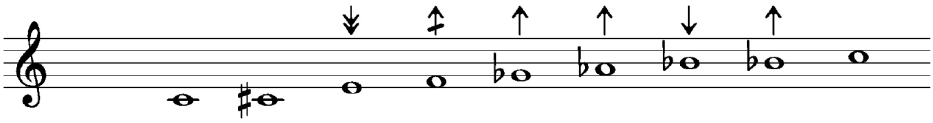
With the first six tones of the partial-tone series, three consonant chords can be formed: the major triad (4 : 5 : 6) and both of its inversions. The traditional 12-step tone system is based on these first six partial tones – the senarium. Within this system, other higher partial tones with sufficient accuracy are included (9., 15., 17. and 19. approximately). With the 15th partial tone it is possible to build-up three more consonant chords: the minor triad (10 : 12 : 15) and both of its inversions. However, with the 7th partial tone, we gain a far better, although unfamiliar, minor triad 6 : 7 : 9 which represents a real contrast to the major triad. But in the traditional tone system there is no 7th partial tone and also no 11th or 13th tone. These “ekmelic” tones are essential for the development of new harmonious chords.

In the (theoretically infinite) progression of the proportion numbers, intervals are defined each by two adjacent numbers and as the numbers increase the intervals become smaller and smaller. New chords can in this way be formed that a selection is made from the total stock of proportion numbers (series of natural numbers) by building arithmetic series. Example: 3, 7, 11, 15, 19, 23, 27 etc.

The so-called inharmonious (pseudoharmonious) part-tones, that can be heard, in particular, with bells, are also created in such series. With such microtonal structures – similar to the nature of the bell spectrum – numerous new harmonious chords can be built-up. As an example, the arithmetic series 3 on 2, i.e. 2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32 etc. Between the proportion number 8 and 32 the following interval structure will be created:



The chord has a very pleasant sound, even when considering the attuned hearing of the system tones to the natural tones of the partial-tone series. If these tones are transposed into the range of an octave, then the following 8 step tone scale is obtained:



Partial tone	16	17	20	22	23	26	28	29	32
Cents	0	105	386,3	551,3	628,3	840,5	968,8	1029,6	1200

The intervals between the notes are:

Cents 105 — 281,3 — 165 — 77 — 212,2 — 128,3 — 60,8 — 170,4

This scale is closely related to the sonance series from which it is derived. This means diatonicism. Deviations from the steps of this scale are to be handled in accordance with the principles of microchromaticism. Also, the parallel use of two or more series is possible and leads to bi- and polytonality, respectively. Thus, by incorporating the ekmelic tones we gain a large number of new harmonious chords. In the same way, the possibilities of the melody shape will be substantially enriched.

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