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Aspects influencing the tuning balance in saxophone performance practice

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Abstract: *Tuning is a crucial factor in any musical performance on saxophone. It is a skill related to auditory perception and can be taught and developed trought the flexibility of the embouchure and air column or using auxiliary fingerings on the instrument to compensate and adjust the tuning. This paper aims to understand the concept of temperament in tuning, as well as the various factors that can affect its stability in saxophone performance. Identifying and being aware of the theoretical functioning of the key opening and closing mechanism and how it affects the rise and fall of frequencies is essential for using correction strategies for these frequencies and, thus, the use of alternative fingerings as a fundamental resource for the saxophonist to improve their tuning. Finally, some study books have been compiled that provide various fingering charts that can be used for tuning correction on the saxophone.*

Key-words: *fingerings, strategies, tuning, tuning correction positions.*

1. Introduction

Tuning is a fundamental aspect in musical practice. It can have various meanings and involves different parameters that guide the entire process (Freire, 2016). This artistic skill can be taught and developed over time through consistent effort (Escórcio 2019). Being out of tune can negatively impact any musical performance, making the experience unpleasant for both the performer(s) and the audience. Precision in tuning is an indispensable aspect of the quality of any instrumental performance (Horbatyuk 2020).

The saxophone is a naturally out-of-tune instrument, requiring careful auditory perception and an understanding of the relationship between sounds and tuning in various contexts, such as different dynamics, the condition of the reeds used, room temperature, and more. Staying in tune is not static; it demands constant attention and adjustment for balance. Since the saxophone is a non-fixed

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tuning instrument, it can change and adjust its tuning and sound quality through the embouchure and air column.

The present work aims to understand tempered tuning, how it can be developed through auditory skills, and what tools can be used to enhance the saxophonist's sense of tuning, thereby mastering their instrument better.

The methodology employed in this work was based on the reading and synthesis of information from articles, theses, books, and websites that address tuning, both in its historical and pedagogical aspects, for various instruments and ensembles.

The work will be divided into two parts, with the first part defining what tuning and temperament are. In the second part, the factors affecting tuning, how they can influence the saxophone, and the presentation of pedagogical material with fingerings that assist in tuning overly unbalanced notes will be explored.

2. Tuning and temperament

Tuning can have more than one meaning. According to Escórcio (2019, 4), „when we talk about tuning, we are talking about a highly debated and diverse concept." This term can have the following meanings:

- "It may be related to the reference pitch followed by musicians," such as the A4 note at 440 Hz (Escórcio 2019, 1);
- It can be „a reproduction of a sound equivalent to another, by comparison where they can be of equal or different timbre" (Horbatyuk 2020, 5);
- Adjusting the „frequency of a note before or during musical performance" (Henrique 2002, 936);
- The relationships between the frequencies of a scale, a suitable adjustment to a system (Goldemberg 2007);
- Adjusting the length of the wind instrument/tension of the strings of a string instrument to tune the sound frequency generated by it based on a scale of defined values (Henrique 2002);
- „Note or notes to which a certain instrument is tuned" (e.g., saxophone in Bb; saxophone in Eb) (Henrique 2002, 936);
- Tuning (tuning process) in the construction of idiophones to relate some of the partials as harmonically as possible (Henrique 2002).

2.1. Types of tuning in instruments

Regarding the tuning of different instruments, they can be classified into 3 categories (Henrique 2002):

- Fixed-tuning instruments – all instruments that cannot modify the tuning minimally during performance, such as the piano.
- Semi-fixed-tuning instruments - all instruments that can vary the tuning during performance within certain limits, such as the saxophone and the clarinet.
- Free-tuning instruments – all instruments that can vary their tuning without limits during performance, as is the case with the voice.

2.2. Temperament

Like the term tuning, temperament can also have more than one definition, and therefore:

- „Adjustment of the tuning of a scale relative to natural tuning, in which some intervals are slightly altered to produce a sense of tuning in the entire scale" (Temperamento, 2003-2020);
- -A system in which intervals deviate from Pythagorean and natural intervals.
- -To temper means to adjust intervals by deviating them from natural intervals (Edilson 2015).

Temperaments arose due to the impossibility of solving the problem of transposition and modulation with existing systems when fixed-tuning instruments, such as the piano, were used (Henrique 2002).

2.3. Temperament and culture

The application of temperament as a system is a measure that emerged to overcome and/or solve problems created by a system understood as deficient. All systems have intervals that benefit at the expense of others.

Different temperaments emerged over time with the aim of solving the transposition and modulation of fixed-tuning musical instruments. Regardless of whether a system was divided into 5ths, 3rds, or half-tones, its intervals would always have an unequal frequency relationship (Edilson 2015). „There is no tuning system that is universally valid. The education and culture of the people familiarize them with a particular sound system" (Edilson 2015).

The musical scale is a fixed sequence of notes/intervals, used to represent a tonality and also structure a tuning system (Freire 2016). According to Goldemberg (2007), any number of notes can be used in musical processes, but practice shows that regardless of culture, the consistent adoption of only a small number.

Western scales are usually formed by seven notes from a range of twelve possibilities distributed over an octave.

It is important for children to hear music with good tuning (tuning of their culture's choice) to make it easier to develop this auditory sensitivity. They should be especially careful to ensure that the instruments being played are well-tuned because otherwise, children will begin to interpret imperfect tuning as a characteristic (Escórcio 2019).

Being out of tune implies a disagreement with the expected sound. When two sounds with close frequencies are played, they interfere with each other, creating a regular modulation of intensity known as beats. Being in tune means avoiding these beats (Horbatyuk 2020; Goldemberg 2007).

What seems pure and correct to us may not have the same meaning for other peoples/cultures and vice versa. The same applies to tuning and temperaments, as the culture to which a particular population belongs promotes a certain system to the forefront of the time and place.

Scales, like their tuning, can vary depending on the cultures in which they are embedded (Escórcio 2019). If multiple instruments play the same note, we perceive all sounds as having the same pitch, even though, in reality, the frequency of these sounds may not be exactly the same. Even vibrato consists of fluctuations in pitch that we do not perceive as constituted by different sounds. The scales most commonly learned in Western music include the whole-tone scale, pentatonic scale, chromatic scale, diatonic scale, etc.

The octave (8th) has been considered a key interval for the construction and definition of many tuning systems because it is the most common interval and is widely accepted by different cultures. This interval has the ability to merge between performers, as two sounds at octave intervals heard simultaneously blend in such a way that most people without musical training think it is a single sound (Escórcio 2019; Henrique 2002). Not all systems use the octave as a base. Scales rarely exceed twelve notes; however, many cultures use musical systems with scales formed by fewer than twelve notes per octave, while others use more than twelve. With the evolution of harmonic principles, new tuning systems have emerged (Escórcio 2019). "There are many cultures whose musical systems use scales formed by fewer than twelve notes per octave" (Horbatyuk 2020, 23).

2.4. Natural tuning

The Natural Tuning is the most characteristic system of the 18th century, being one of the most widely used systems by musicians of that era. It is based on the series of natural harmonics, using pure intervals and respecting natural interval ratios. „The natural diatonic scale corresponds to the arrangement of adjacent sounds of the natural harmonics of a particular sound” (Escórcio 2019, 11).

2.5. Harmonic series and natural intervals

The harmonic series is the set of waves composed of the fundamental frequency and all integer multiples of this frequency of a complex sound; it is the result of the vibration of some type of harmonic oscillator, such as the strings of a string instrument, a wind instrument.

A simple sound is the simplest oscillatory motion that exists, and its graphical representation is a sine wave. A complex sound can be considered a combination of sinusoidal sounds, described as a sum of simple harmonic motions with determined amplitudes and phases (Henrique 2002).

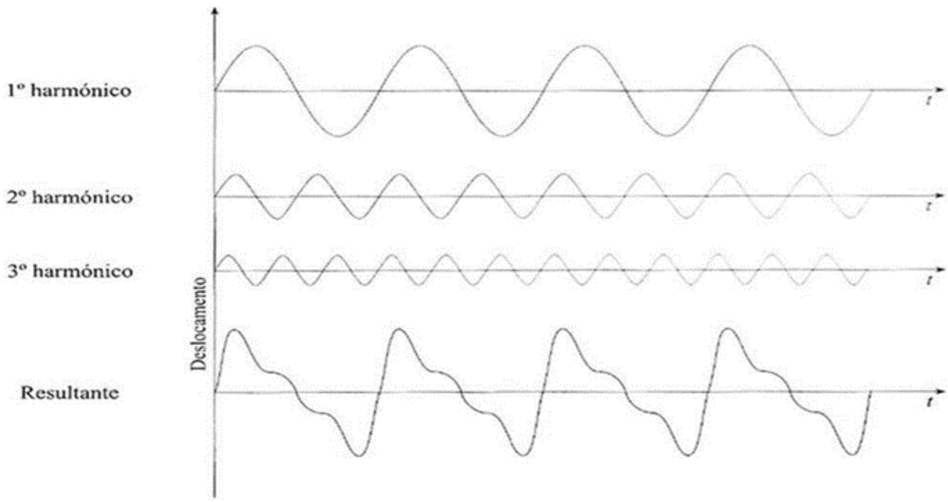

Fig. 1. *Complex Sound (Resultant Sound) Comprising Three Sinusoidal Components (1st, 2nd, and 3rd Harmonics)*

Source: *Henrique 2002, 179*

A complex sound consists of various partials, and these are harmonics. Harmonics have frequencies that are multiples of a base frequency. Musicians may not be familiar with the theory behind the harmonic series, but they are aware of the intervals between them (Figure 2), which never change regardless of the base note/frequency (Henrique 2002). A harmonic series can have any note as its fundamental, and its frequency relationship within the harmonic series will always be the same – natural intervals (derived from the harmonic series): octave, fifth, fourth, major third, minor third, etc. The second partial always has exactly half the wavelength, and therefore twice the frequency, the third partial always has exactly one-third of the wavelength, and so on (Snow 2006).

Fig. 2**.** *Harmonic series of the note C (of its first twenty harmonics). The representation of harmonics with two notes indicates that the sound in question falls between those notes.*

Source: *Henrique 2002, 185*

2.6. Pythagorean temperament

This temperament is based on perfect fifth intervals, arranging the twelve chromatic notes by perfect fifth intervals. Following this cycle, the wolf fifth emerges – the last fifth in this series had to be modified to complete the circle „with maximum perfection," to close the octave according to the Pythagorean system. This note is problematic because it is 23.5 cents shorter compared to the others, not exactly corresponding to the octave (Escórcio 2019; Henrique 2002).

According to Goldemberg (2007), the Pythagorean temperament was the first to be adopted mainly "due to its simplicity and basic symmetry." The fifths and fourths were presented in their ideally pure form as they were considered stable intervals in the stylistic context of that time, while the other intervals (thirds, sixths, and half-tones) were smaller (Temperamento Musical, 2020).

Later, in the 15th century, a preference for natural thirds emerged, and musicians began modifying the Pythagorean temperament to have the thirds closer to natural thirds. Systems based on thirds instead of fifths were created, deliberately deviating from the natural notes. The Mesotonic temperament, for example, is not bad for more classical tonalities but generates a chromatic scale that is too uneven (Temperamento Musical, 2020).

2.7. Equal temperament

Equal temperament, as its name suggests, is the temperament that divides the octave into 12 exactly equal semitones, with each corresponding to a tempered half-step. The 4ths, 5ths, and 3rds are out of tune compared to natural temperament but in a way that is tolerable, as contemporary ears have become accustomed to them (Figure 3). "The tempered 4ths are slightly larger than the natural 4ths, while the tempered 5ths are smaller than the natural 5ths" (Henrique 2002, 933), with only the perfect octaves being in tune (Temperamento Musical, 2020; Henrique 2002; Snow 2006).

This is the most commonly used temperament in the Western world today. Although wind instrument players can perform well in a tempered temperament, they tend to revert to natural temperament when possible (in the absence of fixed-tuning instruments) (Snow 2006).

Note	Just Intonation	Equal temperament	difference Hz
C4	261.63	261.63	0.0
C4#	272.54	277.18	4.64
D4	294.33	293.66	-0.67
E4b	313.96	311.13	-2.84
E4	327.03	329.63	2.60
F4	348.83	349.23	0.4
F4#	367.92	369.99	2.07
G4	392.44	392.00	-0.44
A4b	418.60	415.30	-3.30
A4	436.05	440.00	3.94
B4b	470.93	466.16	-4.77
B4	490.55	493.88	3.33
C5	523.25	523.25	0

Table 1**.** *Comparison between the intervals of just intonation and equal temperament*

2.8. Pitch and tuning throughout History

According to Henrique (2002), the pitch is the absolute height chosen as a standard so that all instruments have the same tuning. Throughout history, there has been a significant disparity in the values used for pitch during certain periods. In the Baroque and Classical periods, the pitch of 415 Hz emerged as a certain reference for the interpretation of these styles. In contemporary times, the current pitch is 440 Hz. Compared to the old pitch (415 Hz), these differ by approximately half a tempered tone (Henrique 2002).

3.The saxophone and tuning

The saxophone is an aerophone instrument, like other wind instruments, and requires careful auditory perception. A saxophonist can slightly adjust the instrument's tuning through subtle changes in embouchure and airflow. To change the overall tuning of the instrument, adjustments to the mouthpiece may be necessary, shortening the instrument if it is flat and lengthening it if it is sharp (Adler 1982; Escórcio 2019).

The most commonly used saxophones today include the soprano (in B♭), alto (in E♭), tenor (in B♭), and baritone (in E♭). They all tend to have a flat low register, a stable middle register, and a very high upper register, presenting a significant challenge for saxophonists in quickly mastering these instruments in terms of tuning. Tuning often depends on the saxophonist's embouchure, as intonation is controlled by it.

Tuning issues are complex and subtle. Even if musicians start a musical piece with precise tuning, it is nearly impossible to maintain perfect tuning throughout the performance. Musicians must adapt to pitch fluctuations (Henrique 2002).

As tuning systems varied according to cultures and eras, it can be stated that tuning is a cultural factor. Music following a temperament different from our culture may give the impression that the musicians are playing out of tune (Escórcio 2019).

Tuning in the saxophone is influenced by various factors that challenge tonal control and stability during performance. Firstly, the instrument's register directly affects tuning, as notes in the lower register tend to be flat, while those in the higher register tend to be sharp. According to Escórcio (2019), it is essential for saxophonists to understand these tendencies and adjust embouchure and vocal flexibility to correct discrepancies, as well as to use auxiliary fingerings to compensate for tuning issues.

Another critical factor is breath support. Lack of air column support can compromise sound production and, consequently, tuning (Horbatyuk 2020). Poor posture and insecure breathing result in a fragile, imprecise sound, leading musicians to compensate by applying more pressure on the embouchure, which can cause injuries and negatively affect sound quality (Escórcio 2019). Proper breath control is thus fundamental for maintaining consistent tuning.

Musicians' concentration is also crucial, as passive listening reduces their ability to correct tuning during performance. According to Martinoff (2009), musical perception requires active processing involving attention and cognitive strategies. Emotional blocks, such as nervousness, can intensify this difficulty by creating tension that disrupts listening and sound production, resulting in tuning variations (Martinoff 2009).

Physiological factors, such as colds or allergies, also affect tuning because obstructions in the respiratory and auditory pathways compromise airflow and hearing. This limitation reduces the musician's ability to clearly hear the sound they produce, impacting tuning (Escórcio 2019). Additionally, instrument quality is a determining factor: lower-quality instruments present more instability in tuning, demanding more adjustments from the musician. Even high-quality instruments do not guarantee perfect tuning, and musicians must constantly adjust to maintain tonal balance (Escórcio 2019).

Room acoustics and climatic conditions are also important variables. Temperature and humidity, for instance, alter reed characteristics and affect the speed of sound propagation, modifying tuning (Henrique, 2002). Saxophonists should warm up the instrument before performing to minimize tonal variations, blowing warm air into the saxophone during pauses to prevent the tube from cooling.

To address these challenges, the use of alternative fingerings is recommended. These slightly modify timbre and tuning by opening or closing specific keys, which is especially useful in higher registers (Figueiredo 2005). Alternative fingering charts can be found in books such as *The Techniques of Saxophone Playing* by Marcus Weiss & Giorgio Netti and *Hello! Mr. Sax* by Jean-Marie Londeix, serving as practical resources for compensating unbalanced notes.

Exercises in auditory perception and embouchure flexibility are also essential. Practicing with tuners and pedal tones (drones) helps musicians develop active listening and tuning control (Escórcio 2019). Recording one's practice provides valuable feedback, allowing saxophonists to assess and adjust their tuning more consciously. Through these practices and resources, saxophonists enhance their ability to adapt to various performance conditions, ensuring stable tuning and superior sound quality.

4. Conclusion

The definition of tuning has evolved over time, influenced by various temperaments, whose purpose was to solve transposition and modulation issues for fixed-tuning instruments like the piano. The most commonly used temperaments today are natural temperament and equal temperament. Although wind instrument players can perform with equal temperament, they tend to revert to natural temperament when the opportunity arises, especially when not playing a fixed-tuning instrument.

Tuning can be considered a cultural factor, as its definition or acceptance varies from culture to culture. This is evident in the creation of various scales, where the number of notes per octave can vary significantly. What may be considered acceptable in one culture might sound out of tune to another due to a lack of familiarity with systems outside their own culture.

Saxophonists have the ability to adjust their tuning during a performance solely through the flexibility of their embouchure and vocal tract. It is essential for them to develop good flexibility and careful auditory perception, which can be cultivated in various ways. In addition to practicing, musicians must be attentive to potential factors that can influence tuning, such as the instrument's register being played, instrument quality, proper breath support, emotional blockages, physiological issues, room acoustics, temperature, humidity, among others. It is also crucial to use alternative fingerings to address notes that are "out of balance" or require tuning adjustments relative to the demands of the score.

In summary, the information presented in this article provides saxophonists with theoretical and practical resources that contribute to better tuning stability and frequency control, whether the notes are written in the score or not.

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