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Novel Numerical Formulas for Asymmetric Steps (17- and 24-Note Systems) to Induce Psychological Effects in Music Therapy

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ABSTRACT

Utilizing numerical rules and algebraic calculations within the frameworks of 17-note and 24-note systems, this study identifies the temperaments and zodiac signs associated with musical scales and links them to specific psychological states and effects. The research introduces novel computational formulas for three types of asymmetrical scales: scales featuring two "witness" (pivotal) notes, scales derived from other modes (**mayehs**), and scales containing variable notes. The **Avaz** forms of classical Iranian music serve as case studies to test the practical application of these formulas. Given that these *Avaz* forms employ quarter-tone intervals, their analysis was conducted using both the 17-note and 24-note numerical systems. Consistent results across both systems confirm the efficacy and robustness of the proposed method. Significantly, the analysis of the Iranian **Radif** using these 17-note and 24-note systems reveals that shared intervals between **Dastgahs** and **Avaz** forms do not necessarily imply a common root in a single primary mode. The findings indicate that—contrary to the theories of certain Iranian experts—the **Avaz** forms of Abu-Ata, Bayat-e Tork, Afshari, and Dashti are independent modes rather than derivatives of **Dastgah-e Shur**; instead, their classification and the structure of the **Radif** are grounded in their shared connection to fundamental human temperaments. This finding highlights the perspective of Iranian thinkers who have emphasized the role of music in enhancing physical and mental well-being.

1. Introduction:

Music theory is a mathematics-based field that examines the consonance and dissonance of notes, as well as the timing and rhythm of melodies, to elucidate the principles of composition and musical structure [10]. Musicians in ancient Iran and Greece, drawing upon the astronomical data and astrological calculations prevalent in their eras, sought to establish connections between musical modes and the signs of the zodiac [17]. Throughout history, certain astronomical concepts have significantly influenced the advancement of science and culture across various civilizations; the zodiac is a prime example of this. Defined as a band across the sky containing the constellations through which the moon and planets appear to pass, the zodiac played a vital role in the astronomical systems of ancient Mesopotamia, ancient Greece, and the Islamic world [12]. This band is divided into twelve equal segments known as signs: Aries (***the Ram***), Taurus (***the Bull***), Gemini (***the Twins***), Cancer (***the Crab***), Leo (***the Lion***), Virgo (***the Maiden***), Libra (***the Scales***), Scorpio (***the Scorpion***), Sagittarius (***the Archer***), Capricorn (***the Goat***), Aquarius (***the Water-bearer***), and Pisces (***the Fish***) [6]. The zodiac is

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linked to the four classical elements—water, earth, air, and fire—which are believed to influence temperament and the balance of the body's humors (***blood, phlegm, yellow bile, and black bile***) [7]. According to prevailing beliefs, human nature is governed by the balance among these four humors—blood, phlegm, yellow bile, and black bile—which collectively shape an individual's overall temperament. Although two of these humors are classified as hot and the other two as cold, they differ in their secondary characteristics: one of the hot humors is dry while the other is moist; similarly, one of the cold humors is dry and the other is moist [18]. The concept of **mezaj** (***temperament***)—derived from the Persian notion of "***intermingling***" or "***mixing***"—is a fundamental principle in traditional Iranian medicine. It refers to a composite state resulting from the combined and opposing effects of the four elemental qualities: water, earth, air, and fire [11].

Within the musical framework of humoral theory, it is posited that specific sound ranges (***frequency ranges***) possess distinct elemental characteristics and corresponding physiological effects. For instance, the high-pitched (or "***treble***") range is described as having a hot and dry temperament; this range exerts a warming effect on an individual's temperament and helps moderate a constitution that is excessively harsh or intense. In contrast, the low-pitched (or "***bass***") range falls into the cold and moist category. Its primary effect is to cool the temperament, making it particularly beneficial and agreeable for individuals with a hot and dry constitution. Music situated in the mid-frequency range—striking a balance between these two extremes—is considered to establish and maintain equilibrium across all four types of temperament [6].

Safī al-Dīn al-Urmawī (d. 1294), in his work **Bahjat al-Rūḥ**, highlighted the astro-musical connections between the twelve Iranian **maqāms** and the constellations of the zodiac. In a diagram, he linked each **maqām** to observations by earlier musicians and specified the seasons and months appropriate for performing these Iranian musical modes. For instance, he designated which melodies should be played during spring—when the sun is in the signs of Aries, Taurus, or Gemini—and during summer—when the sun is in Cancer, Leo, or Virgo—and similarly listed the arrangements for other seasons and modes [19]. Based on genethliacal astrology (natal astrology), the positions of the sun, moon, and planets at the moment of birth can be used to determine an individual's personality, temperament, and behavior [20].

In 1405, Masih Aslani conducted research examining modern numerical systems in musical structures and their relationship with temperaments and constellations [21–26]. In 1405, the artist Daniel Bikas presented research in the field of art [27]. In 1405, Fatemeh Etemadi-Rad carried out research concerning art and tourism [28–30]. In 1400, Mohsen Poursheikhi presented research regarding modern numerical systems and their connection to product manufacturing [31–32]. In 1399, Batool Shahriar analyzed and examined the issues of frost damage, growth, and temperament [33–34]. In 1401, Reza Kakoulvand conducted research investigating numerical systems in the context of computational and experimental fluid dynamics [35–45].

A historical analysis of the formation of the **Dastgāh** system reveals that it initially emerged as a concept of multi-modal performance, rooted in the earlier theoretical framework of "***modal adjacency***." This concept was first documented—albeit briefly—in the fourteenth century. By the sixteenth century, musicological texts had evolved to formulate a systematic method for teaching multi-modal performance. This pedagogical approach formalized four distinct multi-modal suites, each characterized by a cyclical structure: a structure that began with a specific mode (**māyeh**) and concluded by returning to that same mode [15]. Structurally, the Iranian musical repertoire (the **Radif-e Dastgahi**) constitutes a systematic arrangement of modal frameworks, melodic patterns, vocal forms, and fundamental musical vocabulary of the Iranian Plateau. This codification and systematization were primarily undertaken to establish a formal pedagogical mechanism for teaching authentic, standard Iranian music [4]. The **Radif** musical system in Iran comprises seven **dastgahs** (***Mahur, Shur, Homayun, Segah, Chahargah, Nava, and Rast-Panjgah***) and five **avaz** forms (Abu-Ata, Bayat-e Tork, Afshari, Dashti, and Isfahan) [9]. Each **dastgah** is a musical system consisting of multiple **gushehs** (sub-modes or melodic segments), originating from a "***parent mode***" (or principal **maqam**) that serves as its foundation. During performance, the music modulates through various modes in a specific sequence, and each section typically concludes with a **forud** (cadence) that returns the melody to the parent mode [16]. Iranian musical **dastgahs** are not merely melodic systems; according to traditional beliefs, they are thought to evoke distinct psychological and emotional states in the listener. This presumed capacity to influence suggests a profound, structured relationship between specific **dastgahs** and human temperament—as defined in the classical theory of the four humors (the theory of temperaments). To statistically examine this ancient proposition, a General Linear Model (***GLM***) analysis was employed. The results confirm the existence of a significant relationship between temperament type and the psychological trait of "***neuroticism***." It is worth noting that this relationship is observed most strongly in individuals with a melancholic temperament (black bile) and those with a musical affinity for the "***Shur***" mode

[5].

1.1. Introduction to the 17-note and 24-note systems.

This section examines numerical sequences within musical scales and their associated computational methods, based on the intervals found in various octave divisions for 12-, 17-, and 24-note systems. The objective of these systems is to define intrinsic and acquired temperaments and to establish a connection between each scale and the constellations of the Zodiac and the planets. In a 17-note computational system spanning from the initial note "Do" to the final note "***Si***," the ascending process—comprising a total of 17 notes or 16 unequal consecutive intervals—is presented through two models: the "***Makāni***" (***spatial***) and the "***Manzeli***" (***positional/station-based***) models. While these two models share the same sequential order, they employ different numerical values based on prevailing computational rules. As shown in Table 1, the sequence of notes and the corresponding Makāni and Manzeli numbers align with the values established in the Manzeli system. In the Makāni model, the note "Sol Koron" corresponds to the value 10, whereas in the Manzeli model, it corresponds to 2; subsequent notes vary accordingly. The correspondence between note degrees and their numerical values is evident in the Makāni table; however, the numerical variations in the Manzeli table are intended to avoid the use of two-digit numbers [2].

Table 1. 17-Nitye numerical models: "spatial" and "residential" [2].

Note symbols	C	$D_\flat$	$D_\natural$	D	$E_\flat$	$E_\natural$	E	F	$G_\flat$	$G_\natural$	G	$A_\flat$	$A_\natural$	A	$B_\flat$	$B_\natural$	B
Makāni numbers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Manzeli numbers	1	2	3	4	5	6	7	8	9	2	3	4	5	6	7	8	9

The 24-note system is a theoretical model in which an octave is divided into 24 equal "quarter-tone" steps. Within this framework, each note possesses three defining characteristics: (1) a numerical value, (2) an elemental association (earth, water, air, fire), and (3) a planetary correspondence. Theoretically, the expressive qualities and characteristics of each note are determined by the synergistic effects of its assigned element and its celestial counterpart [3], as illustrated in ***Table 2***.

Table 2. "Home" notes in the 24-note system [3].

Names	Saturn	Jupiter	Mars	Sun	Venus	Mercury	Moon
Fire		Fa 5	Sol 9	$La_\natural$ 5	$Si_\natural$ 9	Do 5	Re 9
Wind	$Mi_\natural$ 2	Fa♯ 6		**La** 6	Si 2	Do♯ 6	Re♯ 2
Water	Mi 3	$Sol_\flat$ 7	Sol♯ 3	La♯ 7		$Re_\flat$ 7	$Mi_\flat$ 3
Earth	Mi♯ 4	$Sol_\natural$ 8	$La_\flat$ 4	$Si_\flat$ 8	Si♯ 4	$Re_\natural$ 8	

Note 1.1. The flat sign (♭) lowers the pitch of a note by a semitone.

Note 1.2. The koron sign (𝄮) Lowers the pitch of a note by approximately a quarter-tone.

Note 1.3. The "Suri" symbol (𝄰) raises the pitch of a note by approximately a quarter-tone.

The arrangement of note cells in the table is based on "positional" numbers and—considering numerical value—on "rank" numbers. The logic governing rank numbers in the 24-note system (similar to the 17-note system) inherently prevents the formation of two-digit numbers through numerical reduction.

The rank numbering system operates on a 28-cell matrix divided into nine sections; in this system, the value of each cell is derived through a process of cyclic digit summation, which systematically manages the emergence of two-digit numbers. This research proposes a novel mathematical formulation for this algorithm—termed the "***Cyclic Boundary Theorem***" (***CBT***)—which, to the best of current knowledge, has not previously been described in scientific literature. The CBT5 theorem provides a rule for managing numbers within repeating cycles of nine. Upon reaching the number 9 (***the end of the cycle***), the theorem converts the number 10 into 2 (rather than the standard conversion of 10 to 1), thereby establishing predictable behavior at the boundaries [3].

Cyclic Boundary Theorem (***CBT***). A mathematical framework for periodic number systems, defined as follows:

Notation:

• $k \in Z^+$: Cycle index (each cycle consists of 9 consecutive numbers),

• $P_k = 9$: Base value at the cycle boundary (single-digit numbers) (a constant value for all complete cycles),

• M_k: Final value calculated after applying changes,

• $dr(x)$: Digital root of x (e.g., $dr(123) = 1 + 2 + 3 = 6$).

Main algorithm:

$$M_k = \begin{cases} k, & \text{if } k = 1 \quad \text{(first cycle)}, \\ dr(P_k + 1) + 1 = 2, & \text{if } k \geq 2 \quad \text{(subsequent cycles)}. \end{cases}$$

Key mechanism: At each cycle boundary (when $P_k = 9$): $9 \rightarrow 9 + 1 = 10 \rightarrow dr(10) = 1 \rightarrow 1 + 1 = 2 \rightarrow M_k = 2$.

In other words, upon reaching the digit 9 (the cycle boundary), the system calculates the starting value of the new cycle through the successive summation of digits: first, it sums the digits resulting from the addition of 9 and 1 (since the tenth cell corresponds to that digit); then, it adds 1 to the number 10, yielding 11, and the sum of its digits (1 + 1) equals 2 [3].

1.2. Symmetrical and asymmetrical steps based on 24-tone systems.

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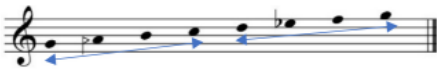
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As established in previous research [2, 3], when analyzing symmetrical and asymmetrical steps, structural similarity between two tetrachords is not sufficient for classification on its own.
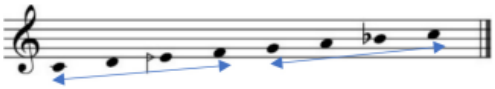
Table 3. The value derived from the intrinsic scale of. Homayoun $A_\flat$

G	$A_\flat$	B	C	Notes	D	$E_\flat$	F	G
9	5	2	5	Numbers	9	3	5	9
$9+5+2+5=21$				Total	$9+3+5+9=26$			



M, (Q +W), H- W - H, W, W

Figure 1. Homayoun $A_\flat$ Advertisement and Isfahan-C



W, M, M- W - W, H, W

Figure 2. The principal scale of - $E_\flat$ Bayate Tork (root note: F), Afshari (root note: G) and Dashti (root note: A).

Note 1.4. The letter "*M*" stands for "***Mojannab***," signifying an interval of a semitone plus or minus a quarter-tone (depending on whether the movement is ascending or descending).

An examination of the intrinsic and inner characteristics of the **Maqams** (or **Dastgahs**) and their variables lies beyond the scope of this article. However, it is worth noting that certain specific notes can hold particular significance within the structure of a **Maqam**. In this regard, two important points are highlighted:

Shāhed note (Witness note): The **Shāhed** is the principal note around which the melody is shaped and to which melodic phrases constantly return [13]. Furthermore, **Shāhed** notes are identified based on the ascending degrees of the **Maqam**.

Variable note: A note that undergoes a temporary change during the performance of a **Gusheh** (whether in ascending or descending motion) [16].

Table 4 illustrates these two specific cases within the main **Maqam**.

Note 1.5. Since the **āvāz**s associated with the **Shur** **dastgāh** are presented as independent scales in the conclusion of this article, their **shāhed** degrees differ from those proposed by Iranian music theorists.

Table 4. Variable and control notes by mode.

No.	Mode	Shāhed Note	Variable Note
1	Abūatā	Dominant then Mediant	Does not have
2	Bayāt-e-tork	Subdominant	Does not have
3	Afshāri	Dominant	Does have
4	Dashti	Sub- mediant	Does have
5	Bayāt-e Isfahān	Subdominant	Does not have

Note 1.6. The degrees of the modes listed in Table 4 are determined based on their intrinsic scale, not their practical or acquired scale.

2. Notation for calculations

The symbols used in this article are presented in Table 5.

Table 5. Computational notation for 17- and 24-tone numerical systems [2, 3].

Explanation	Notation
Asymmetric scale with a Shāhed note of derivatives	St_1
Asymmetric scale with a Shāhed note	$\check{S}t_1$
Asymmetric scale with two Shāhed notes	$\check{S}t_2$
Asymmetric scale with a variable note	$\tilde{\check{S}}t_1$
Sum of the notes	Sn_7
Sum of the notes	Sn_8
Mother scale	$M\check{S}$
First Shāhed note	t_1
Second Shāhed note	t_2
The first tetrachord	x_1
The second tetrachords	x_2
The difference in the sum of the Manzeli numbers of two tetrachords	X
Answers to calculations in the first, second, and third steps	a_1, a_2, a_3
First scale element in computational steps	es_1
Second scale element in computational steps	es_2
Extracted number	e
Answers to calculations in the first, second	a_1, a_2
Obtained number from total calculations	TC
Final innate element of scale (temper notation)	Tes
Scale zodiac constellation	Sz

3. Calculation Rules for 17-Note and 24-Note Systems

The calculation rules for determining the elemental quality and constellation of a scale degree are identical in both the 17-note and 24-note systems. The only difference lies in the method used to obtain the derived value.

I. Determining the element corresponding to the scale degree (the degree's intrinsic nature): Divide the final value obtained from the general calculations by 4; the remainder represents the element of the scale degree—that is:

$TC/4 \equiv Tes.$

Here, the notation $a/c \equiv b$ signifies that b is the remainder of the division of a by c.

Each element is also associated with a specific temperament (humor). The numerical symbols for each element and their corresponding temperaments are presented in ***Table 6*** [1].

Table 6. Numerical symbols for each element and their temperaments [1].

Element	Fire	Wind	Water	Earth
Temper	Warm and dry	Warm and moist	Cold and moist	Cold and dry
Notation	1	2	3	4

Note 3.1. When the remainder is zero, "Tes" and "es" represent the element of Earth, whereas ancient peoples regarded the number 4 as its symbol.

II. Determining the corresponding zodiac constellation: The remainder obtained by dividing the sum of the calculations by 12 indicates the corresponding zodiac constellation; that is:

TC/12 ≡ Sz.

The numerical symbol for each zodiac constellation is listed in ***Table 7*** [2].

Table 7. Numerical symbols of the zodiac constellations [2].

Zodiac	Aries	Taurus	Gemini	Cancer	Leo	Virgo
Notation	1	2	3	4	5	6
Zodiac	Libra	Scorpio	Sagittarius	Capricorn	Aquarius	Pisces
Notation	7	8	9	10	11	12

Note 3.2. When the remainder is zero, "Sz" represents the constellation Pisces (the Fish), though ancient peoples regarded the number 12 as its symbol.

III. The Extracted Number

- The extracted number for the 17-unit numerical system

This number, used for asymmetrical steps according to Table 10, is—based on computational experience—one of the following: 4, 8, or 12. The method for extracting it is as follows:

If the note (***Shahid***) falls within the first three columns (1, 2, 3), the resulting number is 4. If it falls within the second three columns (4, 5, 6), the number is 8. If it falls within the third three columns (7, 8, 9), the number is 12. However, since adding the number 12 does not affect the result, it can be ignored in the calculations (the extracted number is essential for precisely calculating the zodiac constellation corresponding to the scale [2]); as shown in Table 8.

Table 8. Table of the extracted number [2].

Number	1	2	3	4	5	6	7	8	9
Note	Do	Re♭	Re♭	Re	Mi♭	Mi♭	Mi	Fa	
Note	Sol♭	Sol♭	Sol	La♭	La♭	La	Si♭	Si♭	Si

- Extracted value for the 24-note system

The guidelines regarding the value extracted from the 24-note system for asymmetric scales are provided below. Note that this extracted value is essential for the precise calculation of the "Scale Zodiac Constellation."

• Asymmetric scale featuring one or two "***witness***" notes and system derivatives:

The difference between the sums of the "***Manzeli***" numbers associated with the two tetrachords of a scale (X) is calculated as follows:

– If $X := |x_2 - x_1| > 4$, repeatedly subtract 4 from X until it falls within the range $1 \le X \le 4$ (i.e., X mod 4).

– The final extracted value (e) is obtained by multiplying the result by 4 [3].

$$X = |x_2 - x_1|, \quad e := 4 \times \begin{cases} X \bmod 4, & \text{if } X > 4, \\ X, & \text{otherwise.} \end{cases}$$

In an asymmetric scale containing a variable note: the difference between the sums of the "Manzeli" values associated with the scale's two tetrachords is multiplied by 4. If the variable note (V_t) follows the reference note (X), its value is added to 4; if it precedes the reference note (X), it is subtracted from 4. It should be noted that the variable note within the tetrachord is included in the note count.

$$X := x_2 - x_1, \qquad e := 4X,$$

$$e := \begin{cases} X + 4 & \text{if } t,\ \text{Next},\ V_t, \\ X - 4 & \text{if } V_t,\ \text{Before},\ t, \end{cases}$$

Note 3.3. The difference (X) must be between 1 and 4. If X > 4, repeatedly subtract 4 from it until the result falls within this range (for example, if $X = 11$, then 11 - 4 - 4 = 3, and $e = 3 \times 4 = 12$).

Note 3.4. To obtain the extracted value for asymmetric scales that possess a single "***reference***" note, the calculation is performed by examining the first and second tetrachords (four-note segments) starting from the initial note of their respective principal scales.

However, for asymmetric scales with two reference notes, asymmetric scales derived from the *Dastgāh* system, or asymmetric scales containing a variable note, the calculations begin from the reference note.

4. An innovative computational method for 17-note and 24-note numerical systems Before addressing the computational method, it is important to note that the author developed this numerical system and computational approach through trial and error and the examination of various methods. Although these numerical systems function similarly across all types of ethnic and national music, the examples cited in this article demonstrate the calculation method for the *Āvāz* forms of Iranian classical music.

4.1. Asymmetric scales with a reference note.

• 17-note numerical system [2]

a. The sum of the scale's numerical values (comprising eight notes) is multiplied by the reference note; this operation is defined as $a_1 := Sn_8 \times t_1$, where the symbol := denotes definition or assignment.

b. The result of step "a" is divided by 4 to determine the

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scale remainder,
i.e., the scale element (es_1). Then, the element number (es_1)
is multiplied by 4, because there are four seasons in the year (symbolized by the four temperaments or humors); that is:
$a_1/4 \equiv es_1$, $a_2 := es_1 \times 4$.
C. The results of steps A and B are summed. In the final stage for the asymmetric scale, the extracted number *e* is added: $TC = a_1 + a_2 + e$.
• 24-note system [3]: In asymmetric scales featuring a "witness" note, the sum of the scale's seven notes is multiplied by the index of the witness note; the resulting product is then added to the extracted number, as shown below:

$$TC_{\ddot{S}t_1} := (Sn_7 \times t_1) + e.$$

4.2. Asymmetric scales with two witness notes.

• 17-note system

A. The sum of the scale numbers (comprising eight notes) is multiplied by the first witness note, denoted as $a_1 = Sn_8 \times t_1$.
B. The result from step *A* is divided by 4 to determine the scale remainder—specifically, the scale element (es_1). Then, the element value ($\boldsymbol{es_1}$) is multiplied by 4 to obtain a_2; that is:
$a_1/4 \equiv es_1$, $a_2 = es_1 \times 4$.
C. The results of steps A and B are summed to obtain
$a_3 = a_1 + a_2$.
D. The value (es_2) is multiplied by 4, and the result is multiplied by the second witness note (t_2).
$a_3/4 \equiv es_2$, $a_4 = (es_2 \times 4) \times t_2$.
E. The results of steps C and D are summed with the position of the first witness note (incorporating the extracted number—since the extracted number is used only once per computational step), as follows:
$TC = a_3 + a_4 + e$.

• 24-note system

The calculation method is shared with symmetric scales featuring two witness notes; However, in the asymmetric step, the result is added to the extracted value; that is:

• 24-note numerical system
The calculation method is the same for symmetrical scales involving two reference notes;
however, for asymmetrical scales, the result is added to the extracted number, i.e.:
$a_1 = Sn_7 \times t_1$, $TC = (t_2 \times 4) + a_1 + e$.
4.3. Asymmetrical scales derived from the system.
• 17-note numerical system
a. The following mathematical calculations are performed to obtain the parent scale:
$a_1 = Sn_8 \times t_1$,
$a_1/4 \equiv es_1$,

$a_2 = es_1 \times 4$, $M\ddot{S} = a_1 + a_2 + e$.

b. The obtained element number (es_2) is multiplied by 4, and the product is
multiplied by the reference note of the dependent scale (t_2), as follows:

$M\ddot{S}/4 \equiv es_2$,
$a_3 = (es_2 \times 4) \times t_2$.
c. The results from steps (a) and (b) are added to the extracted number as follows:

TC = $M\ddot{S}$ + a_3 + e.
• 24-note numerical system
a. The following mathematical calculations are performed to obtain the parent scale:

$M\ddot{S} = (Sn_7 \times t_1) + e$.
b. The relevant dependent reference note and the number 4 are multiplied together (as follows), and the product is added to the result of step *(a):*

$$a_1 = (t_2 \times 4) + M\ddot{S}$$

c. The result from step "b" is added to the extracted number as follows:

$TC = a_1 + e$.

4.4. Asymmetrical scales with one variable note.

• 17-note system

a. The notes of a scale (eight notes) and one variable note (V_t) are summed, and 1 is subtracted from the total (since there is one extra note); then, the
result is multiplied by the "reference" note (t_1), as shown below:

$\boldsymbol{a_1 = ((Sn_8 + V_t) - 1) \times t_1}$.

b. The result of step "a" is divided by 4 to determine the scale remainder, which is the scale element (es1). Then, the element number ($\boldsymbol{es_1}$) is
multiplied by 4 to obtain a_2; that is:

$\boldsymbol{a_1/4 \equiv es_1}$, $\boldsymbol{a_2 = es_1 \times 4}$.

c. The results of steps "a" and "b" are added to the extracted number,
as follows:

$TC = a_1 + a_2 + e$.

• 24-note system

a. The notes of a scale (seven notes) and one variable note (V_t) are summed, and 1 is subtracted from the total (since there is one extra note); then, the
result is multiplied by the "reference" note (t1), as follows:

$a_1 = ((Sn_7 + V_t) - 1) \times t_1$.

b. The result a1 is added to the extracted number as follows:

$TC = a_1 + e.$

For a better understanding and comparison of the algebraic formulas
for the 17-note and 24-note systems, refer to ***Table 9***.

Table 9. Formulas for 17-note and 24-note musical systems.

Formula Name	17-note Formula	24-note Formula
Asymmetric scales with a Shāhed note	$a_1 := Sn_8 \times t_1$ $a_1 \overset{4}{\equiv} es_1$ $a_2 := es_1 \times 4$ $TC = a_1 + a_2 + e$	$TC_{\ddot{S}t_1} := (Sn_7 \times t_1) + e$
Asymmetric scales with two Shāhed note	$a_1 := Sn_8 \times t_1$ $a_1 \overset{4}{\equiv} es_1$ $a_2 := es_1 \times 4$ $a_3 := a_1 + a_2$ $a_3 \overset{4}{\equiv} es_2$ $a_4 := (es_2 \times 4) \times t_2$ $TC = a_3 + a_4 + e$	$a_1 := Sn_7 \times t_1$ $TC := (t_2 \times 4) + a_1 + e$
Asymmetric scales from derivatives of Dastgāh	$a_1 := Sn_8 \times t_1$ $a_1 \overset{4}{\equiv} es_1$ $a_2 := es_1 \times 4$ $M\ddot{S} = a_1 + a_2 + e$ $M\ddot{S} \overset{4}{\equiv} es_2$ $a_3 := (es_2 \times 4) \times t_2$ $TC = M\ddot{S} + a_3 + e$	$M\ddot{S} := (Sn_7 \times t_1) + e$ $a_1 := (t_2 \times 4) + M\ddot{S}$ $TC := a_1 + e$
Asymmetric scales with a variable note	$a_1 := ((Sn_8 + V_t) - 1) \times t_1$ $a_1 \overset{4}{\equiv} es_1$ $a_2 := es_1 \times 4$ $TC = a_1 + a_2 + e$	$a_1 := ((Sn_7 + V_t) - 1) \times t_1$ $TC := a_1 + e$

Note 4.1. the 17-note system is an incomplete version of the 24-note model. Therefore, there are two key differences in their calculations: • Calculating the octave number in the sum of the notes for each scale: 7 notes are considered in the 24-note system, while 8 notes are calculated in the 17-note system by including the octave number. • The scale element calculations (es1 and es2) are irrelevant in the 24-note system, but become essential for resolving the incomplete cycle inherent to the 17-note system.

2.Result and Discussion

5. Findings

Isfahan - C:8; asymmetric scale with C as the reference note and its derivatives, in accordance with Tables 10–13.

Table 10. 17-note (positional) – reference note C = 1.

G	$A_\flat$	B	C	D	$E_\flat$	F	G	Total
11	13	17	1	4	5	8	11	70
$a_1 = 70 \times 13 = 910,$ $es_1 : 910 \overset{4}{\equiv} 2,$ $a_2 = 2 \times 4 = 8,$ $M\ddot{S}t = 910 + 8 + 8 = 926,$ $es_2 : 926 \overset{4}{\equiv} 2$ $a_3 := (1 \times 2) \times 4 = 8,$ $TC = 926 + 8 + 4 = 938$								

A. The remainder is 2, and its nature is hot and moist.
938 ÷ 4 ≡ 2.
B. The remainder is 2, and the corresponding zodiac sign (constellation) is Taurus (the Bull).
938 ÷ 12 ≡ 2.

Table 11. 17-note (Manzeli) – the *shahed* note is 1.

G	$A_\flat$	B	C	D	$E_\flat$	F	G	Total
3	5	9	1	4	5	8	3	38
$a_1 = 38 \times 5 = 190,$ $es_1 : 190 \overset{4}{\equiv} 2,$ $a_2 = 2 \times 4 = 8,$ $M\ddot{S}t = 190 + 8 + 8 = 206,$ $es_2 : 206 \overset{4}{\equiv} 2$ $a_3 := (1 \times 2) \times 4 = 8,$ $TC = 206 + 8 + 4 = 218$								

A. The remainder is 2, and its temperament is hot and moist.
218 ÷ 4
Remainder: 2
B. The remainder is 2, and the corresponding constellation is Taurus (the Bull).
218 ÷ 12
Remainder: 2.

Table 12. Number of extracted steps (24-note).

G	$A_\flat$	B	C	Notes	D	$E_\flat$	F	G
9	5	2	5	Numbers	9	3	5	9
$9 + 5 + 2 + 5 = 21$				Total	$9 + 3 + 5 + 9 = 26$			
$26 - 21 = 5,$ $5 - 4 = 1,$ $e = 1 \times 4 = 4.$								

Table 13. 24-Note (Manzeli) – The *Shahed* note is C = 5.

G	$A_\flat$	B	C	D	$E_\flat$	F	Sn_7
9	5	2	5	9	3	5	38
$a_1 = 38 \times 5 = 190, eM\ddot{S}t = 4$ $M\ddot{S}t = 190 + 4 = 194.$ $a_1 := (5 \times 4) + 194 = 214$ $TC = 214 + 4 = 218.$							

A: The remainder is 2, and its temperament is hot and moist.
218 ÷ 4≡ 2.
B: The remainder is 2, and the corresponding constellation is Taurus (the Bull).
218 ÷ 12≡ 2.

Abu-Ata – $\mathbf{E}_\flat$: Asymmetrical steps with two "Shahid" (tonic/pivot) notes, as shown in ***Tables 14*** through 17.

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Table 14. 17-note (Makāni) - The Shāheds notes are G = 11, & $E_{\flat}$ = 6

C	D	$E_{\flat}$	F	**G**	A	$B_{\flat}$	C	Total
1	4	6	8	11	14	15	1	60

$a_1 = 60 \times 11 = 660, \quad es_1 : 660 \overset{4}{\equiv} 4,$
$a_2 = 4 \times 4 = 16, \quad a_3 = 660 + 16 = 676.$
$es_2 : 676 \overset{4}{\equiv} 4, \quad a_4 := (6 \times 4) \times 4 = 96,$
$TC = 676 + 96 + 4 = 776.$

A. The remainder is 0, and its temperament is cold and dry.
776 ÷ 4= 0 (remainder).
B. The remainder is 8, and the corresponding constellation is Scorpio.
776 ÷ 12= 8 (remainder).

Table 15. 17-note (Manzeli) – the *shāhed* notes are G (Sol) = 3, and $E_{\flat}$

C	D	$E_{\flat}$	F	**G**	A	$B_{\flat}$	C	Total
1	4	6	8	3	6	7	1	36

$a_1 = 36 \times 3 = 108, \quad es_1 : 108 \overset{4}{\equiv} 4,$
$a_2 = 4 \times 4 = 16, \quad a_3 = 108 + 16 = 124.$
$es_2 : 124 \overset{4}{\equiv} 4, \quad a_4 := (6 \times 4) \times 4 = 96,$
$TC = 124 + 96 + 4 = 224$

A. The remainder is 0, and its nature is cold and dry.
224 ÷ 4
≡ 0.
B. The remainder is 8, and the corresponding constellation is Scorpio.
224 ÷ 12
≡ 8.

Table 16. Value derived from the scale (24-note).

C	**D**	$E_{\flat}$	**F**	**Notes**	**G**	**A**	$B_{\flat}$	**C**
5	9	2	5	**Numbers**	9	6	8	5
$5+9+2+5=21$				**Total**	$9+6+8+5=28$			
$28-21=7, \quad 7-4=3, \quad e=3\times4=12.$								

Table 17. Note 24 - Shahid Sel's note = 9 and $E_{\flat}$ = 2

C	D	$E_{\flat}$	F	**G**	A	$B_{\flat}$	Sn_7
5	9	2	5	9	6	8	44

$a_1 = 44 \times 9 = 396,$
$TC = (2 \times 4) + 396 + 12 = 416.$

A: The remainder is 0, and its nature is cold and dry.
416 ÷ 4 ≡ 0.
B: The remainder is 8, and the corresponding constellation is Scorpio.
416 ÷ 12 ≡ 8.

Bayat-e Tork – F: Asymmetrical scale with **shahed** (pivot note), as presented in Tables 18 through 21.

Table 18. 17-note (Makani) – *Shahed* note: F = 8

C	D	$E_{\flat}$	**F**	G	A	$B_{\flat}$	C	Total
1	4	6	8	11	14	15	1	60

$a_1 = 60 \times 8 = 480, \quad es_1 : 480 \overset{4}{\equiv} 4,$
$a_2 = 4 \times 4 = 16,$
$TC = 480 + 16 + 12 = 508$

Table 19. 17-note (Manzeli) - The Shāheds note are F = 8.

C	D	$E_{\flat}$	**F**	G	A	$B_{\flat}$	C	Total
1	4	6	8	3	6	7	1	36

$a_1 = 36 \times 8 = 288, \quad es_1 : 288 \overset{4}{\equiv} 4,$
$a_2 = 4 \times 4 = 16,$
$TC = 288 + 16 + 12 = 316$

A. The remainder is 0, and its nature is cold and dry.
316 ÷ 4≡ 0.
B. The remainder is 8, and the corresponding zodiac sign is Cancer (the Crab).
316 ÷ 12≡ 4.

Table 20. Value derived from the scale (24-note).

C	**D**	$E_{\flat}$	**F**	**Notes**	**G**	**A**	$B_{\flat}$	**C**
5	9	2	5	**Numbers**	9	6	8	5
$5+9+2+5=21$				**Total**	$9+6+8+5=28$			
$28-21=7, \quad 7-4=3, \quad e=3\times4=12.$								

Table 21. Note 24 (Manzali) – Shahed note, F = 5.

C	D	$E_{\flat}$	**F**	G	A	$B_{\flat}$	Sn_7
5	9	2	5	9	6	8	44

$a_1 = 44 \times 5 = 220,$
$TC = 220 + 12 = 232.$

A: The remainder is 0, and its nature is cold and dry.
232 ≡ 0 (modulo 4).
B: The remainder is 8, and the corresponding constellation (or division) is Cancer (the Crab).
232 ≡ 4 (modulo 12).

Afshari - Sol (G): An asymmetrical scale with one variable note, as shown in ***Tables 22*** through 25.

Table 22. 17-note (positional) – Reference note Sol (G) = 11, and the variable note is... $A_\flat$ =13

C	D	$E_\flat$	F	**G**	$A_\flat$	A	$B_\flat$	C	Total
1	4	6	8	11	13	14	15	1	73
$a_1 = (73-1)\times 11 = 792,$ $es_1 : 792 \overset{4}{\equiv} 4,$ $a_2 = 4\times 4 = 16,$ $TC = 792+16+4 = 812$									

A. The remainder is 0, and its temperament is cold and dry.
812 ÷ 4≡ 0.
B. The remainder is 8, and the corresponding zodiac sign (mansion) is Scorpio.
812 ÷ 12≡ 8.

Table 23. 17-note (mansion) system – witness note G = 3 and variable note... $A_\flat$ = 5

C	D	$E_\flat$	F	**G**	$A_\flat$	A	$B_\flat$	C	Total
1	4	6	8	3	5	6	7	1	41
$a_1 = (41-1)\times 3 = 120,$ $es_1 : 120 \overset{4}{\equiv} 4,$ $a_2 = 4\times 4 = 16,$ $TC = 120+16+4 = 140$									

A. The remainder is 0, and its temperament is cold and dry.
140/4 ≡ 0.
B. The remainder is 8, and the corresponding constellation is Scorpio.
140 ÷ 12≡ 8.

Table 24. The value derived for the scale (24-note).

C	**D**	**$E_\flat$**	**F**	**Notes**	**G**	**$A_\flat$**	**A**	**$B_\flat$**	**C**
5	9	2	5	**Numbers**	9	5	6	8	5
$5+9+2+5=21$				**Total**	$9+5+6+8+5=33$				
$33-21=12\,,\quad 12-(2\times 4)=4,$ $4\times 4=16,\quad e=16+4=20.$									

Table 25. 24-Note System (Manzeli) – Dominant note (Shāhed)G = 9; the variable note is G, $A_\flat$ = 5

C	D	$E_\flat$	F	**G**	$A_\flat$	A	$B_\flat$	Sn_7
5	9	2	5	9	5	6	8	49
$a_1 = (49-1)\times 9 = 432,$ $TC = 432+20 = 452.$								

Table 26. 17-Note (Positional)Scale – Dominant note (Shāhed) A = 14; the note is variable. $A_\flat$ = 13

C	**D**	$E_\flat$	F	G	$A_\flat$	**A**	$B_\flat$	C	Total
1	4	6	8	11	13	14	15	1	73
$a_1 = (73-1)\times 14 = 1008,$ $es_1 : 1008 \overset{4}{\equiv} 4,$ $a_2 = 4\times 4 = 16,$ $TC = 1008+16+8 = 1032$									

A. The remainder is 0, and its nature is cold and dry.
1032 ÷ 4 = 0 (remainder).
B. The remainder is 0, and the corresponding zodiac sign is Pisces (the Fish).
1032 ÷ 12 = 0 (remainder).

Table 27. 17-Note (Manzeli) Scale – Dominant note (Shāhed): A (6); the variable note is... $A_\flat$ = 5

C	**D**	$E_\flat$	F	G	$A_\flat$	**A**	$B_\flat$	C	Total
1	4	6	8	3	5	6	7	1	41
$a_1 = (41-1)\times 6 = 240,$ $es_1 : 240 \overset{4}{\equiv} 4,$ $a_2 = 4\times 4 = 16,$ $TC = 240+16+8 = 264$									

A. The remainder is 0, and its temperament is cold and dry.
264 ÷ 4 = 0 (remainder 0)
B. The remainder is 0, and the corresponding zodiac sign is Pisces (the Fish).
264 ÷ 12 = 0 (remainder 0).

Table 28. Extracted step value (24-note).

C	**D**	**$E_\flat$**	**F**	**Notes**	**G**	**$A_\flat$**	**A**	**$B_\flat$**	**C**
5	9	2	5	**Numbers**	9	5	6	8	5
$5+9+2+5=21$				**Total**	$9+5+6+8+5=33$				
$33-21=12\,,\quad 12-(2\times 4)=4,$ $4\times 4=16,\quad e=16-4=12.$									

Table 29. 24-note [Maqam] (Manzeli) – Dominant note (Shahid): A (A = 6) and variable note. $A_\flat$ = 5

C	D	$E_\flat$	F	G	$A_\flat$	**A**	$B_\flat$	Sn_7
5	9	2	5	9	5	6	8	49
$a_1 = (49-1)\times 6 = 288,$ $TC = 288+12 = 300.$								

A: The remainder is 0, and its nature is cold and dry.
300 ≡ 0 (modulo 4).
B: The remainder is 0, and the corresponding zodiac sign is Pisces (the Fish).
300 ≡ 0 (modulo 12).

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The results of the calculation steps for the seven systems are presented in ***Tables 30*** through 38.

Table 30. Symmetric scale with a reference note (derived) for the Isfahan Maqam in the 17-note system.

Model	$M\breve{S}t$	es_2	t	a_3	e	TC	Tes	Sz
Makāni	926	2	1	8	4	938	2	2
Manzeli	206	2	1	8	4	218	2	2

Table 31. Symmetrical scale with the *shāhed* note (derived from *Maqām-e Isfahān*) in the 24-note system.

Model	$M\breve{S}t$	t_1	a_1	TC	Tes	Sz
Manzeli	194	5	214	218	2	2

Table 32. Symmetrical scale with two reference notes for the *Abu-Ata* maqam in the 17-note system.

Model	Sn_8	t_1	a_1	es_1	a_2	a_3	t_2	es_2	a_4	e	TC	Tes	Sz
Makāni	60	11	660	4	16	676	6	4	96	4	776	0	8
Manzeli	36	3	108	4	124	4	6	4	96	4	224	0	8

Table 33. Symmetrical scale with two reference notes for the *Abu-Ata* maqam in the 24-note system.

Model	Sn_7	t_1	a_1	t_2	e	TC	Tes	Sz
Manzeli	44	9	396	2	12	416	0	8

Table 34. Spatial asymmetric scale model for the *Bayāt-e Tork* witness note in the 17-note system.

Model	Sn_8	t_1	a_1	es_1	a_2	e	TC	Tes	Sz
Makān	60	8	480	4	16	12	508	0	4
Manzeli	36	8	288	4	16	12	316	0	4

Table 35. Asymmetrical step relative to the reference note for Bayāt-e Tork in the 24-note system.

Model	Sn_7	t_1	a_1	e	TC	Tes	Sz
Manzeli	44	5	220	12	232	0	4

Table 36. Asymmetric scale with one variable note for the Afshari and Dashti modes in the 17-note system.

Mode	Model	Sn_9	t_1	Vt	a_1	es_1	a_2	e	TC	Tes	Sz
Afshāri	Makān	73	11	13	792	4	16	4	812	0	8
Afshāri	Manzeli	41	3	5	120	4	16	4	140	0	8
Dashti	Makān	73	14	13	1008	4	16	8	1032	0	0
Dashti	Manzeli	41	6	5	240	4	16	8	264	0	0

Table 37. Asymmetric scale to a variable note for Afshāri and Dashti in 24- note.

Mode	Model	Sn_8	t_1	a_1	e	TC	Tes	Sz
Afshāri	Manzeli	49	9	432	20	452	0	8
Dashti	Manzeli	49	6	288	12	300	0	0

Table 38. Innate temperament and zodiac constellation table Āvāzs classical Iranian music.

Mode	Innate temperament	Zodiac sign	zodiac temperament
Isfahān	Warm and moist	Taurus	Cold and dry
Abūatā	Cold and dry	Scorpio	Cold and moist
Bayāt-e-Tork	Cold and dry	Cancer	Cold and moist
Afshāri	Cold and dry	Scorpio	Cold and moist
Dashti	Cold and dry	Pisces	Cold and moist

6. Discussion

This article, the fourth in a series of studies on "numerical systems in music," is grounded in the principle that a fundamental link exists between music, numbers, and astronomy—a connection that, in turn, yields psychological insights. Scholars and sages have consistently emphasized this principle from the time of Pythagoras to the present day. However, throughout history, this relationship has largely remained at a theoretical and philosophical level, never having been systematically articulated through precise mathematical formulas.

In the present study, this long-standing connection transcends its purely theoretical status for the first time, achieved through an innovative approach and sustained effort involving trial and error. Various types of asymmetrical musical scales have been analyzed using precise mathematical and logical formulations. This numerical model not only bridges classical theories with modern therapeutic applications but also establishes a framework for a formula-based understanding of the profound effects musical scales exert on the human psyche.

Numerical systems offer a powerful framework for the rigorous analysis of music theory, leading to a deeper understanding of the psychological states and effects evoked by melodies and scales. As illustrated in Table 38, the **Dashti** mode—possessing an innate temperament of "cold and dry"—is linked to the element of "***Earth***," a connection that fosters patience and endurance. In contrast, its acquired temperament—aligned with the zodiac sign of Pisces (**Hut**)—is "***cold and moist"*** and corresponds to the element of "Water," a temperament that instills flexibility, poise, and profound tranquility.

Beyond these theoretical foundations, empirical evidence and long-standing cultural traditions have long affirmed the effectiveness of "***Dashti***" in providing solace to the bereaved. This efficacy likely stems from its capacity to facilitate emotional release (catharsis), enabling individuals to process their pain through expression. From a scientific perspective, this phenomenon can be viewed as the gradual tempering of the "***fiery***" intensity of grief and separation by the balancing elements of "*water*" and "*earth*" inherent in the nature of this musical scale. By harmonizing these elemental energies, Dashti helps channel and organize deep emotions, ultimately bolstering the individual's resilience and endurance in the face of adversity.

The music of every culture possesses unique rules and theories, the precise analysis and calculation of which require systematic approaches. In this article, five renowned **Avaz** forms of Iranian music are examined using 17-note and 24-note numerical systems; by presenting the relevant mathematical formulas, the study

offers a comprehensive analysis for understanding Iranian music.

7. Conclusion:

The results derived from the 17-note numerical system—despite differences in the valuation of spatial and positional models—align perfectly with those of the 24-note system. This congruence validates the computational method and lends further credibility to the innovative approach of employing numerical systems to analyze musical scales.

Given the novel concepts introduced through these numerical systems in music theory, consulting the earlier articles cited in the references is essential for a deeper and more accessible understanding of the subject. Accurately identifying the starting note of each scale is crucial for theoretical analysis, a task accomplished through numerical computational methods. For instance, some Iranian musicologists have classified scales such as Abu-Ata, Bayat-e Tork, Afshari, and Dashti as subsets of ***Dastgah-e Shur***—due to shared structural features and the fact that the ***Shahed*** (***pivotal***) note of *Shur* precedes the *Shahed* notes of these other ***maqams***—even though the fundamental (intrinsic) scale of these *maqams* actually begins one degree lower than the *Shahed* note of ***Dastgah-e Shur***. It is worth noting that the initial calculations were based on various premises. Since the validity of any calculation depends on achieving consistent results across both the 17-note (***Makka'i and Manzeli***) and 24-note systems, evaluating the aforementioned ***Avaz*** forms from the perspective of those musicologists (in comparison to ***Dastgah-e Shur***) fails to yield consistent results. This study demonstrates that such a classification, from the viewpoint of historical musicians, stems from the shared tuning systems between these ***maqams*** and ***Dastgah-e Shur***.

Prior to the formation of the ***Dastgāh*** system, Iranian music was organized based on the *Maqām* system and evolved into its current form through a logical progression. Even ***Āvāz-e Abu-Ata***—which was previously considered a type of *Forūd* (cadence) within *Dastgāh-e Shūr*—was later recognized as an independent Iranian ***āvāz*** due to its inherent capacity and scope. Calculations based on numerical systems demonstrated that Abu-Ata possesses an independent nature and is not derived from ***Shūr***.

It is worth noting that there are two perspectives regarding the ***Shāhed*** (witness/pivot) note in *Āvāz-e Abu-Ata*: some identify it as having a single *Shāhed* note, while others attribute two *Shāhed* notes to it. Calculations performed using numerical scale systems revealed that this ***Maqām*** features two *Shāhed* notes; positing a single ***Shāhed*** note resulted in inconsistencies across three different tables. Analyses further indicated that ***Āvāz-e Isfahan*** is derived from ***Dastgāh-e Homāyūn*** and—among the seven ***Dastgāhs*** and five renowned ***Āvāzes*** of Iranian music—is the only *Āvāz* that belongs to a principal ***Dastgāh***.

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Appendices

I. Zodiac Constellation and Corresponding Planet: Each of the twelve sections of the zodiac—through one of which the sun passes each month—roughly corresponds to the solar months. Each zodiac sign has a ruling planet as follows: 1- Aries: Mars; 2- Taurus: Venus; 3- Gemini: Mercury; 4- Cancer: Moon; 5- Leo: Sun; 6- Virgo: Mercury; 7- Libra: Venus; 8- Scorpio: Mars; 9- Sagittarius: Jupiter; 10- Capricorn: Saturn; 11- Aquarius: Saturn; 12- Pisces: Jupiter [2, 3].

II. Innate Scale: A scale whose interval structure—from a specific degree to its octave—is identical to that of other scales of the same type, thereby serving as the fundamental (innate) form relative to them. Consequently, in a 17-note system, a single scale can be expressed through 17 different modal rotations (modes), yet only one of these 17 interval patterns functions as the reference (innate) scale [2, 3].

III. Acquired Scale: A scale that begins on a different degree but exactly preserves the interval structure of the innate scale. For example, the acquired "Mahur" scale on the note "Fa" is obtained by applying the interval pattern of the innate "Mahur" (based on "Do")—but starting from the note "Fa" [2, 3].

IV. Practical Scale: A scale where performance starting from a specific note determines the character and emotional mood of that *Maqam*. For instance, the natural minor scale (A minor) is derived from the natural major scale (C major); however, the *actual* A minor scale—that is, the scale as it is truly performed—begins on the ascending sixth degree of the C major scale, and it is precisely this starting point that establishes the identity of that mode [2, 3].

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