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An innovative 17-note numerical system and its computational method for identifying the psychological effects and states of musical pitch



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ABSTRACT

For centuries, Iranian philosophers and scientists believed that music was related to sciences such as mathematics, the four human temperaments, and astronomy; unfortunately, none of them provided explicit laws or mathematical formulas to prove their claims. Addressing this gap, this paper introduces a 17-note numerical system along with a computational method designed to identify the psychological effects and emotional states associated with musical pitches. New concepts, in particular, the “intrinsic pitch” and the “acquired pitch,” are explored with their distinctions and applications in musical and numerical frameworks. Furthermore, this study uses computational techniques and principles of numerical analysis to investigate the early modes of the 7-note system in Iranian classical music. Although the 17-note system shares interval similarities with the 18-note system of the ancient Abjad, it has fundamental differences in numerical valuation, computational methodology, structural efficiency, and systematic approach to application. These findings can be applied in music therapy and music theoretical studies as an innovative, number-based method that provides deeper insight into the psychological properties of musical steps. The results show a significant correlation between the psychological states evoked by musical steps and their inherent temperamental characteristics, and by identifying the zodiac constellations associated with each step, the psychological effects of melodies can be further discerned. For example, the analysis of the main mode in the Chargah system shows that the feeling of excitement is aligned with the warm and dry psychological quality. Furthermore, the computational approach showed the Chargah to be astrologically aligned with the Leo zodiac sign, showing that its melodies naturally evoke the qualities of courage, excitement, and radiant joy.

1. Introduction

Scientific music is a mathematical discipline that discusses the harmony and dissonance of notes, as well as the timing of melodies, to determine how music is composed [11]. Ancient Iranian and Greek musicians tried to relate musical modes to the zodiac using astronomical information and the astronomical calculations of authorities [25]. Some concepts in the history of astronomy have seriously influenced the development of science and culture in many regions. The concept of the zodiac is one of them. The zodiac, as

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a band of constellations, in which the observable movements of the moon and planets occur, played an important role in the astronomy of ancient Mesopotamia, ancient Greece, and Islamic countries. Ideas related to the zodiac had not only astronomical, but also astronomical and religious significance. The history of the Mesopotamian zodiac is of particular importance, as it had a direct impact on the formation of ideas about the zodiac in ancient Greece and Islamic countries, and through them in Europe [16]. The zodiac is divided into twelve equal parts called the zodiac signs: Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius, and Pisces [2]. Various sections of the book Bahjat al-Ruh (The Joy of the Soul) by Safi al-Din Urmavi (d. 1294) refer to the relationship between the twelve positions of Persian music and the constellations of the zodiac. In a diagram, he associates each position with the zodiac and attributes it to the ancestors [31]. The zodiac has the properties of the four elements (water, earth, wind, and fire), and they affect the "***temperament***" of the body and the humors (blood, phlegm, bile, and phlegm) [1]. It is believed that bodies are created based on the four humors, namely blood, phlegm, bile, and phlegm. Two of them are hot and two are cold. There is a difference between the two; One is hot and dry, the other is hot and humid, one is cold and dry, and the other is cold and humid [26]. Temperament in Persian means combination and in traditional Iranian medicine refers to a quality that arises from the interaction between the opposing qualities of the four elements (water, earth, air, and fire) [15]. Human mood is strongly influenced by mental states. Some of these states affect human mood quickly and some slowly. For example, anger releases heat suddenly, while joy releases heat gradually. Fear drives heat inward suddenly (the face turns white), but sadness drives heat inward gradually and, in the long run, causes bilious diseases. Table 1 lists six important mental states and the quality of each [24].

Table 1. Relationship between human temperament [24]

Temperament quality	Psychological quality
Warm and dry	*Anger*
Warm and dry	*Excitement*
Warm and moist	*Worry*
Cold and moist	*Fear*
Cold and dry	*Depression*
Cold and dry	*Sorrow*

GLM analysis results indicate that temperament type is associated with the trait of neuroticism. This relationship is stronger in individuals with a melancholic temperament (the "black bile" temperament) and those inclined toward the "***salty constitution***" [5]. High-pitched (high-frequency) musical sounds are characterized as warm and dry; they temper harshness and warm the temperament. Low-pitched (low-frequency) sounds are cold and moist, cooling the temperament; listening to them is highly beneficial for individuals with a warm and dry temperament. Music situated in the range between low and high pitches maintains the balance of all temperaments [2]. Based on the twelve signs of the zodiac, Iranian philosophers devised twelve musical **maqams** (modes) that are recognized as fundamental pillars [27]. These twelve **maqams** (along with others) were performed within the framework of ancient Iranian music, which comprised seventeen degrees and tonalities. For instance, Safi al-Din Urmawi formulated the **Oshshaq** *maqam* based on each of the seventeen degrees of the scale. Consequently, in accordance with this rule, each **maqam** encompasses seventeen tonalities, bringing the total number of tonalities across the twelve primary **maqams** to 204 (12 × 17 = 204) [9].

However, the current system is limited to seven **dastgāh**s, which are themselves subdivided into numerous ****naghmeh***s (melodic motifs) [29]. A historical examination of the emergence of the **dastgāh** reveals that the concept originally referred to multimodal performance and was rooted in the idea of modal adjacency—a concept first briefly documented in the fourteenth century. By the sixteenth century, a pedagogical concept regarding multimodal performance appeared in musical texts, outlining four sets of multimodal performances; these sets began with a specific mode and returned to that same mode [21].
The Iranian musical repertoire (the ****radif-e dastgāhi***) comprises a collection of modes, melodies, motifs, and tonal frameworks intrinsic to the music of the Iranian Plateau, systematically organized to facilitate the teaching of authentic Iranian music to students [4]. The names of the seven principal **dastgāh**s are: Shur, Mahur, Homayun, Chahargāh, Segāh, Navā, and Rāst-Panjgāh [17]. A **dastgāh** is a musical structure composed of various segments known as ****gusheh***s; it begins with a central mode that serves as the foundation or "mother mode." As the piece progresses, the music traverses a structured sequence of different modes. These sections typically conclude with a *forud* (cadence) that returns the music to the mother mode [22].
n 1405, Masih Aslani conducted research examining modern numerical systems in musical modes and their relationship with temperaments and constellations [32–38]. In 1405, the artist Daniel Bikas presented research in the field of art [39]. Fatemeh Etemadi-Rad presented research on art and tourism in 1405 [40–42]. In 1400, Mohsen Poursheikhi conducted research investigating modern numerical systems and their connection to

product manufacturing [43–44]. In 1399, Batul Shahriyar analyzed the effects of frostbite on growth and temperament [45–46]. Through the efforts of Reza Kakoulvand in 1401, research was conducted examining numerical systems in conjunction with computational and experimental fluid dynamics [47–57].

2. History of the Ancient "Abjad" Music Notation System

In the history of Iranian music, numbers were employed in four distinct ways: first, to designate scale degrees—though the alphabet was used for this purpose in melody notation [13]; second, to calculate intervals relative to one another [10]; third, for rhythm or *īqāʿāt* (the rhythmic system of ancient music) [12]; and fourth, in the realm of the physics of sound (acoustics) [7, 23]. However, since this article focuses on the first aspect (notation methods), a brief explanation regarding the practices of the pioneers of this art in Iran follows.

Al-Kindi (801–873) represented the notes of an octave using the letters of the alphabet from ***Alif*** to ***Kaf*** and repeated them in the second octave. The octave was referred to as ***alladhī bi-l-kull***, and its structure—like that of ancient Greece—was based on the minor scale; it began on the note A (as the fundamental note or *awt*) and spanned two octaves, as shown in ***Figure 1***:

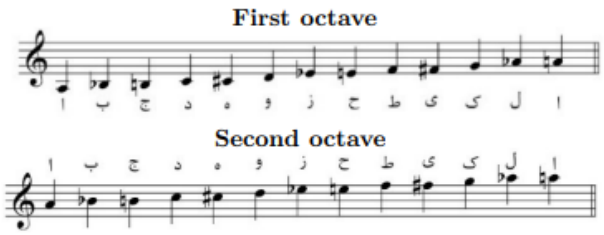


Figure 1. (a) First octave, (b) Second octave

Following him, Abu Nasr al-Farabi (d. 950 CE)—the great Iranian musician and musicologist known as the "Second Teacher" (or ***al-Mu'allim al-Thani***) and recognized in the West as "***Alpharabius***"—continued efforts to resolve the two-octave problem by extending the sequence of letters beyond "**Lam**" into the second octave (i.e., "***Mim***," "***Nun***," "Sin," etc.). However, it is evident that this initiative failed to distinguish note degrees within the octave, as each letter of the *Abjad* system represents a specific numerical value. Thus, the sequence progresses from the letter "**Alif**" (equivalent to 1) to the letter "Ya" (reaching 10); yet the letter "Kaf" is assigned the value of 20, whereas it ought to represent the eleventh note. Ibn Zayla al-Isfahani (d. 1048 CE)—a prominent student of Ibn Sina—successfully resolved this issue by appending two letters following the eleventh degree in the ***Abjad*** system: "***Ya***" (*Y + A = 11*) and "Yib" (*Y + B = 12*). Subsequently, another Iranian artist, Safi al-Din Abd al-Mu'min al-Urmawi (d. 1294 CE)—as demonstrated in his seminal work *Al-Adwar fi al-Musiqa* (The Cycles in Music)—expanded upon this approach and formulated a method of composition that was adopted by Iranian and other Muslim musicians who followed him. In Safi al-Din al-Urmawi's system, the octave comprises 18 notes (including the repetition of the note "Do" or "Ut"); since these 18 notes create 17 musical intervals, this structure is designated as the "17-part system" (as illustrated in Figure 2, assuming "Do" as the fundamental note).



Figure 2. Safi al-Din al-Urmawi's design.

The works of Abd al-Qadir Maraghi (d. 1434) [18]—Iran's last traditional musicologist—indicate that, following the method of Safi al-Din Urmawi [30], he proceeded from the note "***Yah***" to "***Lah***" in the second octave (which he termed "*Zīl-i Kalū-yi Murattayn*"). Table 2 illustrates the details described above.

Table 2. Layout of Safi al-Din Urmawi's 18-note Abjad table.

C	$D_\flat$	$D_\sharp$	D	$E_\flat$	$E_\sharp$	E	F	$G_\flat$	$G_\sharp$	G	$A_\flat$	$A_\sharp$	A	$B_\flat$	$B_\sharp$	B	C
ا	ب	ج	د	ه	و	ز	ح	ط	ی	ک	ل	م	ن	س	ع	ف	ص
Alef	Be	Jim	Dāl	He	Vāv	Ze	Hhe	Tā	Ye	Yā	Yab	Yaj	Yad	Yah	U	Yaz	Yahh
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

2. Research Objectives:

1.Primary Objective

To introduce and examine the relationship between the four human temperaments, the constellations of the zodiac, and musical scales within a single-octave range (based on a 17-note division) through numerical calculations and the formulation of scientific rules.

2. Secondary Objectives

a. To propose new definitions—such as "innate scale," "acquired scale," and "operational scale"—to analyze the relationship between music, temperament, and astrology.

b. To investigate and analyze the reasons for the historical absence of computational methods and rules to substantiate this relationship.

c. To formulate a scientific framework linking music, mathematics, temperament theory, and astrology based

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on the 17-note system.

3. Introduction to the 17-Note Numerical System (An Innovative Theory)

This study introduces innovative numerical sequences for musical scales and their corresponding computational methods—based on shared intervals across various scales within an octave and within the framework of 12-, 17-, and 24-note systems. These systems were developed to determine innate and acquired temperaments and to elucidate the connections between zodiac constellations, planets, and specific musical scales. This paper represents the first study to examine the complex relationship between the four human temperaments, zodiac constellations, and musical scales. Although earlier scholars acknowledged the existence of this connection, they failed to formulate a logical, systematic, or computational framework to explain it. Furthermore, their interpretations often diverged significantly, leading to ambiguity. While the 17-note system shares interval similarities with the ancient 18-note "***Abjad***" system, it differs substantially in terms of approach and application.

The present study employs computational methods to address this central topic and deepen our understanding of these remarkable connections.

Within a numerical-computational system comprising 17 notes—defined by the starting note "***Do***" and the concluding note "***Si***"—an ascending process (consisting of a total of 17 notes or 16 consecutive unequal intervals) is presented through two models: "***Makāni***" and "Manzeli." While sharing the same sequence and common computational rules, these two models utilize different numerical values. As illustrated in Table 3, the sequence of notes and the numerical values for the Makāni model are specified, while Table 4 presents the numerical values for the Manzeli model based on the established valuation system.

Table 3. Makāni 17-note numerical model.

Note symbols	C	$D_♭$	$D_♯$	D	$E_♭$	$E_♯$	E	F	$G_♭$	$G_♯$	G	$A_♭$	$A_♯$	A	$B_♭$	$B_♯$	B
Note names	Do	$Re_♭$	$Re_♯$	Re	$Mi_♭$	$Mi_♯$	Mi	Fa	$Sol_♭$	$Sol_♯$	Sol	$La_♭$	$La_♯$	La	$Si_♭$	$Si_♯$	Si
Makāni numbers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Table 4. Manzeli's numerical model (17)

Note symbols	C	$D_♭$	$D_♯$	D	$E_♭$	$E_♯$	E	F	$G_♭$	$G_♯$	G	$A_♭$	$A_♯$	A	$B_♭$	$B_♯$	B
Note names	Do	$Re_♭$	$Re_♯$	Re	$Mi_♭$	$Mi_♯$	Mi	Fa	$Sol_♭$	$Sol_♯$	Sol	$La_♭$	$La_♯$	La	$Si_♭$	$Si_♯$	Si
Manzeli numbers	1	2	3	4	5	6	7	8	9	2	3	4	5	6	7	8	9

In the "***Makāni***" model, the value assigned to the "Sol Koron" note is 10, whereas in the "***Manzeli***" model, it is 2; the values of subsequent notes shift accordingly. While the correspondence between note degrees and their numerical values is evident in the Makāni table, the logic behind the numerical changes in the Manzeli table is to avoid two-digit numbers. Thus, the formula for determining note values in the Manzeli model is as follows:

a) For notes with single-digit numbers: The number of intervals relative to the starting note (assigned number 1) is summed.

b) For notes with two-digit numbers: The number of intervals relative to the starting note (assigned number 2) is summed, and then—to avoid a two-digit result—the digits of the resulting number are added together.

In other words, let x and b be natural numbers, such that:

x represents the note number in the Manzeli model table.

b represents the number of intervals relative to the starting note "C" (as shown in Figure 3).

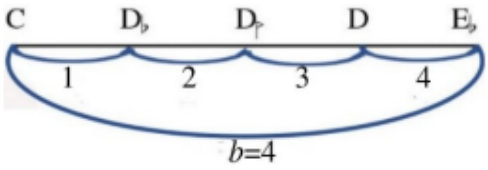


Figure 3. Number of intervals from the starting note.

$$x = \begin{cases} b+1, & 1 \le b \le 8, \\ b+2, & 9 \le b \le 16. \end{cases}$$

When $1 \le b \le 8$, the "***Manzeli***" (positional/house-based) number of the note in question is simply x itself.

When $9 \le b \le 16$ and x is a two-digit number (expressed as $x = b_1b_2$), its digits are summed ($b_1 + b_2$) to obtain the Manzeli number of the note.

For example, to find the number for the note Gd, the interval is b = 9, which corresponds to $x = 2 + 9 = 11$; the sum of the digits is 2 (*i.e.*, $1 + 1 = 2$).

Note: Semitones are represented as chromatic intervals in the "***Makāni***" (spatial/locational) and "***Manzeli***" tables. However, if a diatonic semitone exists within a scale, one unit is subtracted from that note's number. For instance,

the Makāni number for "A" is 12 and its Manzeli number is 4, whereas for the position "G♯",

the Makāni number is 11 and the Manzeli number is 3. This characteristic also applies to "Holdrian comma" values for chromatic and diatonic semitones; specifically, 5 commas are assigned to chromatic notes and 4 commas to diatonic notes.

4. Characteristics of the Makāni and Manzeli Note Model Tables

First, it should be noted that the proposed models (Makāni and Manzeli) have no precedent
in existing Iranian or Western music theories regarding the described objective.
Therefore, the present article is introduced as the first study in this field to examine this important topic using computational methods. Based on the findings of this study regarding the structure of the 17-note system, achieving accurate computational results requires summing all the numerical values—as well as the remainders obtained from division by 12—and dividing the total by 9. As shown in Tables 5 and 6, the sum of the numerical values of all notes in the "Makāni" model is 153; the sum of the digits of this figure is 9. Furthermore, the remainder obtained by dividing the sum of the note values by 12 is 9, confirming the validity of the Makāni model. In the "***Manzeli***" model, the sum of all numerical values is 89—a figure linked to the total number of notes (17). The remainder of 89 divided by 12 is 5, indicating the presence of five notes with a quarter-tone (**koron**) interval, as detailed in Table 6.

Table 5. Calculation method for the spatial system

The sum of numbers of nites of Makāni table	Sum of the digits
$1+2+3+4+5+6+7+8+9+10+11+12+13+14+15+16+17=153$	1+5+3=9
Quotient	**Remainder**
$153 \div 12 = 12$	9

Table 6. Calculation method for home system

The sum of numbers of nites of Manzeli table	Sum of the digits
1+2+3+4+5+6+7+8+9+2+3+4+5+6+7+8+9 = 89	$8+9=17$
Quotient	**Remainder**
$89 \div 12 = 7$	5

5. Examining the Iranian musical repertoire based on the 17-note system

Before delving further into this topic to substantiate and validate the concepts of the "***Makani***" and "***Manzeli***" tables—as well as their calculation methods—a brief explanation is necessary. Regarding the interval structure of the notes within two tetrachords (four-note segments) of a scale separated by a "major second," these structures are classified within numerical systems into two types: symmetrical scales and asymmetrical scales.

5.1. Symmetrical scales. Symmetrical scales consist of two consecutive tetrachords with identical interval patterns, separated by a whole tone (a major second); examples include the **Dastgahs** of Mahur, Rast-Panjgah, and Chahargah, as illustrated in Figure 4. However, structural and formal similarity between these two tetrachords is not sufficient on its own; the sum of the note values for both tetrachords must also correspond to the "***Manzeli***" 24-note numerical system (which will be explained in the subsequent article).

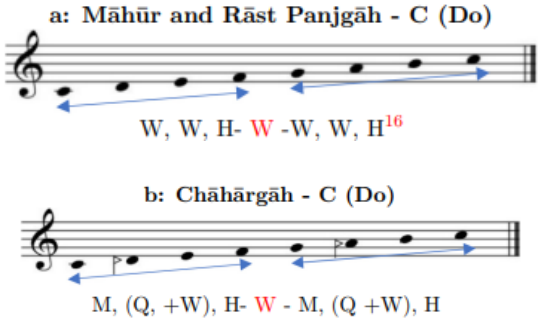


Figure 4. Examples a and b of symmetrical scales.

Note 1: The letter "M" denotes "Mojannab," representing an interval of a semitone plus or minus a quarter-tone (ascending or descending).
Note 2: The letter "Q" denotes a quarter-tone.

5.2. Asymmetrical scales. Asymmetrical scales consist of two dissimilar tetrachords separated by a whole-tone interval (major second), creating an octave with contrasting interval patterns. This structure results in a non-uniform pattern—such as those found in musical scales like Segah, Shur, Nava, and Homayun—as illustrated in Figure 5 (note that the numerical values derived from each tetrachord system will differ due to the use of the 24-note system).

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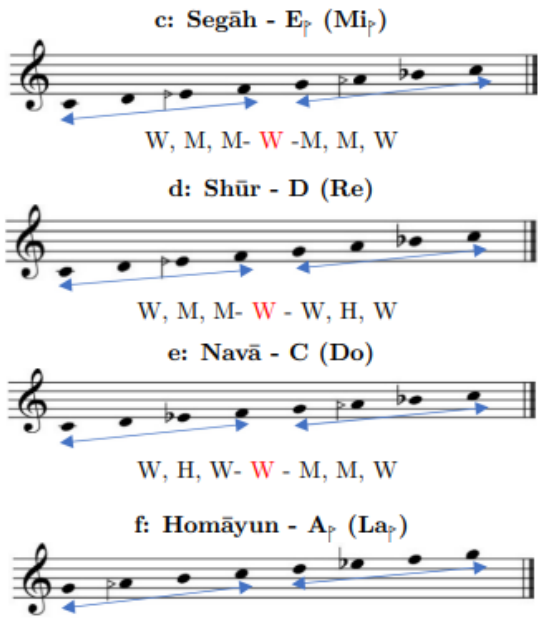


Figure 5. Example of asymmetrical steps from c to f.

Since the aim of this article is to introduce the 17-note system and its associated calculations, the intrinsic characteristics of the scales and their variables are not addressed; nevertheless, the notes within a scale play a significant role.

It is important to note the following point here:

The ****Shahed**** note: The ****Shahed**** note is the principal note around which the melody is structured and to which melodic phrases constantly return [19]. Furthermore, the ****Shahed**** notes are presented based on the ascending degrees of the scale.

Table 7. Specifications of scale Modes

Number	Mode	Shāhed note
1	Māhūr	*Tonic*
2	Rāst-Panjgāh	*TonicthenSupertonic*
3	Chāhārgāh	*Tonic*
4	Segāh	*Mediant*
5	Shūr	*Tonic*
6	Navā	*Tonic*
7	Homāyun	*Supertonic*

6. Computational notation

The symbols used in this paper are presented in Table 8.

Table 8. Calculation notation of 17-note numerical system

Explanation	Notation
Symmetrical scale with a Shāhed note	St_1
Symmetrical scale with two Shāhed notes	St_2
Asymmetric scale with a Shāhed note	St_1
Sum of the notes	Sn_8
First Shāhed note	t_1
Second Shāhed note	t_2
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, and third steps	a_1, a_2, a_3
Obtained number from total calculations	TC
Final innate element of scale (temper notation)	Tes
Scale zodiac constellation	Sz

7. Computational rules of the 17-note numerical system

Through a lengthy computational process of trial and error in cases (I) and (IV), and with the assistance of the old established system in cases (II) and (III), the following rules have been established: (I) The result of calculations in the Makāni and Manzeli systems must be the same. (II) To obtain the scale element (innate temper scale), divide the last number in the total calculation by 4, and the remainder will be the scale element, i.e., $TC/4 \equiv Tes$.

The notation $a/c \equiv b$ means that b is the remainder of a divided by c. Each element is also associated with a temperament. The numerical notation of each element and its temperaments are indicated in ***Table 9*** [3].

Table 9. Numerical symbols of each element and their temperaments [3].

Element	Fire	Wind	Water	Earth
Temper	Warm and dry	Warm and moist	Cold and moist	Cold and dry
Notation	1	2	3	0

Note: When the remainder is zero, "Tes" and "es" represent the earth element, although ancient peoples regarded the number 4 as its symbol.

(III) Determining the corresponding zodiac sign: The remainder obtained by dividing the sum of the calculations by 12 indicates the corresponding zodiac sign; that is:

$TC / 12 \equiv Sz$.

The numerical symbol for each zodiac sign is shown in ***Table 10***.

Table 10. Numerical symbols of the zodiac constellations.

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: When the remainder is zero, "Sz" represents the constellation Pisces (the Fish), though in ancient times, the number 12 was used to symbolize it.

(IV) Instructions regarding the extracted number: This number—used for asymmetric steps according to Table 10—is determined through calculation to be either 4, 8, or 12. The extraction method is as follows: if the "***Shahid***" (witness) note falls within the first three columns (1, 2, 3), the number is 4; if it falls within the second three columns (4, 5, 6), the number is 8; and 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 final result, it may be disregarded in the calculations (the extracted number is essential for precisely calculating the zodiac constellation corresponding to the step).

Table 11. *Table of extracted values*

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

Since the 17-note system is an incomplete model derived from the 24-note system, the table above was constructed based on the 24-note sequence, after which the notes not utilized in the 17-note system were removed; consequently, the ninth cell of the first row remains empty.

8. Calculation Method for the 17-Note Numerical System

Before discussing the calculation method, it should be noted that the author arrived at this numerical system and calculation method through trial and error and the examination of various approaches.

Furthermore, the symbols defined in Table 7 of the 17-note numerical system are used for the calculations. Although the numerical values associated with "***positional***" and "***rank***" significance function identically across all types of folk and national music, the following examples specifically examine the initial scales within the repertoire of traditional Iranian music; naturally, each musical genre will employ its own specific calculation method based on its modal foundations.

8.1. Symmetrical scales with a single "***Shahed***" (witness/pivot) note.

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

b. The result from step (a) is divided by 4 to determine the remainder—identified as the "***scale element***" (es1). Subsequently, the value of the element (es1) is multiplied by 4 (reflecting the four seasons of the year, which symbolize the four temperaments/humors); that is:

$a_1 / 4 \equiv es_1$, $a_2 := es_1 \times 4$.

c. The results from steps (a) and (b) are summed; that is, $TC = a_1 + a_2$.

8.2. Symmetrical scales with two "Shahed" notes.

a. The sum of the scale's numerical values (comprising eight notes) is multiplied by the value of the first Shahed note: $a_1 := Sn_8 \times t_1$.

b. The result from step (a) is divided by 4 to determine the remainder—identified as the scale element (es_1). Then, the scale element (es1) is multiplied by 4 to obtain

a_2:$a_1 / 4 \equiv es_1$, $a_2 := es_1 \times 4$.

c. The results of steps (a) and (b) are summed; that is, $a_3 = a_1 + a_2$.

d. The second reference note is multiplied by the element value obtained in step (c) as follows:

$a_3 / 4 \equiv es_2$, $a_4 := es_2 \times t_2$.

e. The results of steps (c) and (d) are summed to yield $TC = a_3 + a_4$.

8.3. Asymmetric scales with a reference note. For calculations involving asymmetric scales with a reference note, the same method used for symmetric scales with a reference note is applied; the difference is that in the final step for the asymmetric scale, the value e (derived from the preceding steps and the values of a1 and a_2) is added to the sum, resulting in TC = $a_1 + a_2$ + e.

9. Findings

Mahur-Do (C): Symmetrical scale with a *shahed* (reference note), as shown in Tables 12 and 13.

Table 12. (Makāni) - The Shāhed note is Do =1

C	D	E	F	G	A	B	C	Total
1	4	7	8	11	14	17	1	63

$a_1 = 63 \times 1 = 63$, $es_1 : 63 \overset{4}{\equiv} 3$, $a_2 = 3 \times 4 = 12$, $TC = 63 + 12 = 75$.

A

17: The remainder is 3, and its temperament is cold and moist.

75 ÷ 4

Remainder: 3

B

18: The remainder is 3, and the corresponding constellation is Gemini (The Twins).

75 ÷ 12

Remainder: 3

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Table 13. (Manzili) – The *Shāhed* note is "Do" (C).

C	D	E	F	G	A	B	C	Total
1	4	7	8	3	6	9	1	39
$a_1 = 39 \times 1 = 39,$ $es_1 : 39 \overset{4}{\equiv} 3,$ $a_2 = 3 \times 4 = 12,$ $TC = 39 + 12 = 51.$								

A. The remainder is 3, and its temperament is cold and moist.
51 ÷ 4
Remainder: 3
B. The remainder is 3, and the corresponding constellation (or degree) is Gemini (***Jowza***).
51 ÷ 12
Remainder: 3
Chahargah – Root note (C or Do): The scale symmetrical to the *shahed* (witness) note, as presented in Tables 14 and 15.

Table 14. (Spatial) – The witness note is "Do" (C).

C	D♭	E	F	G	A♭	B	C	Total
1	3	7	8	11	13	17	1	61
$a_1 = 61 \times 1 = 61,$ $es_1 : 61 \overset{4}{\equiv} 1,$ $a_2 = 1 \times 4 = 4,$ $TC = 61 + 4 = 65.$								

A. The remainder is 1, and its nature is hot and dry.
65 ÷ 4
Remainder: 1
B. The remainder is 5, and the corresponding constellation is Leo (the Lion).
65 ÷ 12
Remainder: 5

Table 15. (Manzali) – The witness note is "Do" (C).

C	D♭	E	F	G	A♭	B	C	Total
1	3	7	8	3	5	9	1	37
$a_1 = 37 \times 1 = 37,$ $es_1 : 37 \overset{4}{\equiv} 1,$ $a_2 = 1 \times 4 = 4,$ $TC = 37 + 4 = 41.$								

A. The remainder is 1, and its temperament is hot and dry.
41 ≡ 1 (mod 4)
B. The remainder is 5, and the corresponding constellation (or zodiac sign) is Leo (the Lion).
41 ≡ 5 (mod 12)
Rast-e Panjgah – C (Do): A symmetrical scale with two "***witness***" (shahid) notes, as shown in Tables 16 and 17.

Table 16. (Positional) – The *shahed* notes are "Do" (degree 1) and "Re" (degree 4).

C	D	E	F	G	A	B	C	Total
1	4	7	8	11	14	17	1	63
$a_1 = 63 \times 1 = 63,$ $es_1 : 63 \overset{4}{\equiv} 3,$ $a_2 = 3 \times 4 = 12,$ $a_3 = 63 + 12 = 75,$ $es_2 : 75 \overset{4}{\equiv} 3,$ $a_4 = 3 \times 4 = 12,$ $TC = 75 + 12 = 87.$								

A. The remainder is 3, and its temperament is cold and moist.
87 ÷ 4 = ... with a remainder of 3.
B. The remainder is 3, and the corresponding constellation is Gemini.
87 ÷ 12 = ... with a remainder of 3.

Table 17. (Manzali) – The *shahed* notes are "Do" (1st degree) and "Re" (4th degree).

C	D	E	F	G	A	B	C	Total
1	4	7	8	3	6	9	1	39
$a_1 = 39 \times 1 = 39,$ $es_1 : 39 \overset{4}{\equiv} 3,$ $a_2 = 3 \times 4 = 12,$ $a_3 = 39 + 12 = 51,$ $es_2 : 51 \overset{4}{\equiv} 3,$ $a_4 = 3 \times 4 = 12,$ $TC = 51 + 12 = 63.$								

A. The remainder is 3, and its temperament is cold and moist.
63 ÷ 4
Remainder: 3
B. The remainder is 3, and the corresponding constellation (or degree) is Gemini.
63 ÷ 12
Remainder: 3
Segah – Ed (Middle): An asymmetrical scale with a "Shahid" (witness/pivot) note, as shown in Tables 18 and 19.

Table 18. (Makāni) - The Shāhed note $(\text{Mi}\flat = 6)$

C	D	E♭	F	G	A♭	B♭	C	Total
1	4	6	8	11	13	15	1	59
$a_1 = 59 \times 6 = 354,$ $es_1 : 354 \overset{4}{\equiv} 2,$ $a_2 = 2 \times 4 = 8,$ $TC = 354 + 8 + 8 = 370.$								

A. The remainder is 2, and its temperament is hot and moist.
370 ÷ 4
Remainder: 2
B. The remainder is 10, and the corresponding constellation is Capricorn (the Goat).
370 ÷ 12
Remainder: 10

(tonic/reference) note, as presented in Tables 22 and 23.

Table 19. (Manzeli) - The Shāhed note ($Mi_{\flat}$ =6)

C	D	$E_{\flat}$	F	G	$A_{\flat}$	$B_{\flat}$	C	Total
1	4	6	8	3	5	7	1	35

$a_1 = 35 \times 6 = 210, \quad es_1 : 210 \overset{4}{\equiv} 2, \quad a_2 = 2 \times 4 = 8,$
$TC = 210 + 8 + 8 = 226.$

A. The remainder is 2, and its temperament is hot and moist.
226 ÷ 4
Remainder: 2
B. The remainder is 10, and the corresponding constellation (or division) is Capricorn.
226 ÷ 12
Remainder: 10
Homāyun - $A_{\flat}$ ($La_{\flat}$): An asymmetrical scale with *_shahed_* (witness) notes, as shown in Tables 20 and 21.

Table 20. (Makāni) - The Shāhed note ($La_{\flat}$ =13)

G	$A_{\flat}$	B	C	D	$E_{\flat}$	F	G	Total
11	13	17	1	4	5	8	11	70

$a_1 = 70 \times 13 = 910, \quad es_1 : 910 \overset{4}{\equiv} 2, \quad a_2 = 2 \times 4 = 8,$
$TC = 910 + 8 + 8 = 926.$

A. The remainder is 2, and its temperament is hot and moist.
926 ÷ 4
Remainder: 2
B. The remainder is 10, and the corresponding constellation is Taurus (the Bull).
926 ÷ 12
Remainder: 2

Table 21. (Manzeli) - The Shāhed note ($La_{\flat}$ =5)

G	$A_{\flat}$	B	C	D	$E_{\flat}$	F	G	Total
3	5	9	1	4	5	8	3	38

$a_1 = 38 \times 5 = 190, \quad es_1 : 190 \overset{4}{\equiv} 2, \quad a_2 = 2 \times 4 = 8,$
$TC = 190 + 8 + 8 = 206.$

a. The remainder is 2, and its temperament is hot and moist.
206 ÷ 4 = ... with a remainder of 2.
b. The remainder is 10, and the corresponding constellation (or degree) is Taurus (the Bull).
206 ÷ 12 = ... with a remainder of 2.
Nava – Note C: An asymmetrical scale with a *_shahed_*

Table 22. (Positional) – The reference note is "Do" (DO) (1 = DO).

C	D	$E_{\flat}$	F	G	$A_{\flat}$	$B_{\flat}$	C	Total
1	4	5	8	11	13	15	1	58

$a_1 = 58 \times 1 = 58, \quad es_1 : 58 \overset{4}{\equiv} 2, \quad a_2 = 2 \times 4 = 8,$
$TC = 58 + 8 + 4 = 70.$

A. The remainder is 2, and its nature is hot and moist.
70 ÷ 4
Remainder: 2
B. The remainder is 10, and the corresponding constellation is Capricorn (the Goat).
70 ÷ 12
Remainder: 10

Table 23. (Manzali) – The *Shahed* note is "Do" = 1.

C	D	$E_{\flat}$	F	G	$A_{\flat}$	$B_{\flat}$	C	Total
1	4	5	8	3	5	7	1	34

$a_1 = 34 \times 1 = 34, \quad es_1 : 34 \overset{4}{\equiv} 2, \quad a_2 = 2 \times 4 = 8,$
$TC = 34 + 8 + 4 = 46.$

A. The remainder is 2, and its temperament is hot and moist.
46 ÷ 4
Remainder: 2
B. The remainder is 10, and the corresponding constellation (or degree) is Capricorn (the Goat).
46 ÷ 12
Remainder: 10
Shur – Degree D (Re): Asymmetrical scale with the "Shahed" (tonic/dominant) note (in accordance with Tables 24 and 25).

Table 24. (Positional) – The *Shahed* note, Re (D), is 4.

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

$a_1 = 60 \times 4 = 240, \quad es_1 : 240 \overset{4}{\equiv} 4, \quad a_2 = 4 \times 4 = 16,$
$TC = 240 + 16 + 8 = 264.$

A. The remainder is 0, and its temperament is cold and dry.
264 ÷ 4 = ... with a remainder of 0
B. The remainder is 0, and the corresponding

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constellation is Pisces (the Fish).
264 ÷ 12 = ... with a remainder of 0.

Table 25. (Manzeli) – The observed value is Re = 4.

C	**D**	$E_\flat$	F	G	A	$B_\flat$	C	Total
1	4	6	8	3	6	7	1	36
$a_1 = 36 \times 4 = 144, \quad es_1 : 144 \overset{4}{\equiv} 4, \quad a_2 = 4 \times 4 = 16,$ $TC = 144 + 16 + 8 = 168.$								

A. The remainder is 0, and its temperament is cold and dry.
168 ≡ 0 (modulo 4)
B. The remainder is 0, and the corresponding constellation is Pisces (the Fish).
168 ≡ 0 (modulo 12)
The results of the calculation steps for the seven systems—in both the "***spatial***" and "***manzil***" (lunar mansion) models—are shown in Tables 26 through 31, and their temperaments and constellations are presented in Table 32.

Table 26. Symmetric scale of the Makāni spatial model based on the witness node.

Mode	Sn_8	t_1	a_1	es_1	a_2	TC	Tes	Sz
Māhūr	63	1	63	3	12	75	3	3
Chāhārgāh	61	1	61	1	4	65	1	5

Table 27. Symmetrical scale of the Manzeli model based on the witness note.

Mode	Sn_8	t_1	a_1	es_1	a_2	TC	Tes	Sz
Māhūr	39	1	39	3	12	51	3	3
Chāhārgāh	37	1	37	1	4	41	1	5

Table 28. Spatial model with a symmetrical scale and two reference notes.

Mode	Sn_8	t_1	a_1	es_1	a_2	a_3	t_2	es_2	a_4	TC	Tes	Sz
Rāst-Panjgāh	63	1	63	3	12	75	4	3	12	87	3	3

Table 29. Symmetrical scale Manzeli model with two Shāheds note

Mode	Sn_8	t_1	a_1	es_1	a_2	a_3	t_2	es_2	a_4	TC	Tes	Sz
Rāst-Panjgāh	39	1	39	3	12	51	4	3	12	63	3	3

Table 30. Asymmetric "Makāni" scale model for the "reference" note.

Mode	Sn_8	t_1	a_1	es_1	a_2	TC	Tes	Sz
Segāh	59	6	354	2	8	370	2	10
Homāyun	70	13	910	2	8	926	2	2
Navā	58	1	58	2	8	70	2	10
Shūr	60	4	240	4	16	264	0	0

Table 31. Asymmetric scale Manzeli model to a Shāhed note)

Mode	Sn_8	t_1	a_1	es_1	a_2	TC	Tes	Sz
Segāh	35	6	210	2	8	226	2	10
Homāyun	38	5	190	2	8	206	2	2
Navā	34	1	34	2	8	46	2	10
Shūr	36	4	144	4	16	168	0	0

3. Result and Discussion:

10. Discussion:

In this article, the primary temperaments of the seven **Dastgāhs** (modal systems) of Iranian music are evaluated. To facilitate understanding and ensure clarity, the following points are significant:
1. The temperaments of musical scales are categorized into two types: innate temperaments and acquired temperaments. Innate temperament is calculated numerically based on scale intervals, whereas acquired temperament arises from factors that alter the primary temperament. Consequently, the effects of a note's innate temperament remain largely intact, even after an acquired temperament is superimposed. For instance, an individual with a specific innate temperament and its associated structural characteristics (such as physique and skeletal structure relative to other innate temperaments) retains the traits of that innate temperament throughout their life, even if they acquire a different temperament. Thus, the nature of the acquired temperament in any given scale depends on factors such as the season, the associated zodiac sign, the corresponding planet, and the tonality of the specific *Dastgāh*. For example, as shown in the table of innate temperaments for the seven traditional Iranian musical **Dastgāhs**, the **Dastgāh** of Mahur possesses a "cold and moist" nature, yet it is dominated by the "warm and moist" characteristics of the zodiac sign Gemini.
2. To verify the accuracy of results concerning "innate" and "zodiacal" scales, one must arrive at identical outcomes using four calculation tables (comprising two models of the 17-note system, one "house-based" model of the 24-note system for scales featuring quarter-tone intervals, and one 12-note "house-based" model for equal-tempered scales without quarter-tones—all of which will be explained in future articles). Initially, the result must be consistent across the two models (spatial and house-based) of the 17-note system, and subsequently, the same result must be obtained in the 24-note system. For instance, the Mahur scale on "Do" (C) is identified as having a "cold and moist" temperament and the zodiac sign "Gemini" in both the 17-note and 24-note house-based models; however, if a

scale is not of the innate type, the results across the system's calculation models will not align. By way of example, the Mahur scale on "Fa" (F) presents a "cold and dry" temperament and the zodiac sign "***Cancer***" in the spatial model, a "cold and dry" temperament and the zodiac sign "Scorpio" in the house-based model, and a "warm and dry" temperament and the zodiac sign "Sagittarius" in the 24-note system. Consequently, the Mahur scale on "Fa" is not an innate scale. In other words, the calculations regarding the aforementioned degrees or scales are examined from the perspective of each of the seventeen degrees, and only one consistent scale—the innate scale—emerges across those three tables (two from the 17-note system and one from the 24-note system).

3. In the table correlating the inherent temperament and zodiac sign (constellation) with the seven *Dastgāhs* presented in the findings, some *Dastgāhs* share the same element and zodiac sign yet possess distinct characteristics for various reasons. For instance, the **Segāh** and **Navā** modes both correspond to the sign of Capricorn (the Goat), yet their interval structures differ; this situation is analogous to genetic variation, where individuals born under the same zodiac sign may exhibit different traits due to genetic diversity. Awareness of these nuances is significant in the field of music therapy—much like two food items that taste different but share similar properties. Just as individuals have varying tastes regarding food, their psychological preferences differ when it comes to choosing music. Similarly, the **Māhur** and **Rāst-Panjgāh** **Dastgāhs**, which belong to the sign of Gemini (the Twins), are considered members of the same family and exhibit similar behavior, yet they possess distinct temperaments.

Ultimately, the fundamental difference between the 17-note (16-interval) numerical system and the ancient 18-note (17-interval) system—based on the **Abjad** numeral system—can be described as follows:

1. Structural difference: The ancient model is an 18-note (17-interval) system, whereas the current model is a 17-note (16-interval) system. In the 17-note system, the starting note "*Do*" (C) and the octave note "*Do*" are both equated to the number "1," as they return to the starting point of their progression, much like a circle; However, in the 18-note system—designated by the symbol "Yahh" (ی‌ه)—this note corresponds to the number 18 (derived from the Abjad letters "Y" [10] and "H" [8], which sum to 18); this implies that, just like the other notes, a distinct position has been allocated for the octave note.

2. Difference in numerical valuation: In the Abjad system—aside from the numerical variation of the note "***Do***" (C) across different octaves—the note "***Sol***" (G), represented by the letter "Ye," corresponds to the value 11; conversely, in the 17-note system, the numerical value of "Do" remains constant across octaves, and in the "***Manzali***" model, "***Sol***" corresponds to the value 3; the values of subsequent notes differ accordingly.

3. Difference in calculation method: Calculations in the Abjad-based 18-note system rely on determining degrees and interval ratios between notes, whereas the 17-note system is founded on algebraic calculations and numerical systems.

4. Difference in systematic function: The 18-note system is structured around the Abjad alphabet and is utilized for notating and deriving **maqam** cycles and note positions; in contrast, the 17-note numerical system is a computational framework for determining temperamental characteristics, the influence of constellations on music, and mathematical-logical relationships within music theory.

At first glance, the 17-note numerical system and its associated calculations may appear similar to the Abjad-based 18-part division theory; in reality, however, these two systems represent distinct and separate concepts. Regarding the relationship between temperaments, constellations, and the principal **maqams** of Iranian musical scales—while earlier scholars did not formulate specific criteria or computational rules to define this connection—existing findings suggest that this perspective may indeed hold validity. Unfortunately, the nomenclature of musical scales in contemporary music differs from that used by ancient Iranian scholars, making it difficult to precisely interpret the insights of past musicians. Nevertheless, the hypothesis held by some contemporary musicians—that the ancient **maqām** known as "***Oshshāq***" corresponds to the principal scale of the *****Dastgāh-e Māhūr*****—aligns with the findings of this study.

Despite the absence of explicit formulas or calculations from ancient musicians, their insights appear to have been largely intuitive, transmitted to subsequent generations orally or through personal observations. This article is the first study to examine this relationship by introducing a 17-note numerical system and its associated computational method.

11. Conclusion:

Computational results confirm that, notwithstanding differences in note valuation between "***spatial***" (*****makāni*****) and "positional" (*****manzeli*****) models, the formulation of the 17-note numerical system evaluates the principal scales of the seven *****dastgāhs***** of contemporary Iranian traditional music in a consistent and reliable manner. A significant relationship exists between these numerical evaluations and the psychological characteristics attributed to each *****maqām***** (mode).

Furthermore, computational findings indicate that the

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psychological states associated with each *maqam* (musical mode) align significantly with its intrinsic temperamental quality. For instance, excitement—characterized by a "hot and dry" psychological quality—corresponds to *Dastgah-e Chahargah*; anxiety—"hot and moist"—to *Dastgah-e Segah*; love and contemplation—"hot and moist"—to *Dastgah-e Homayoun*; dignity and tranquility—"cold and moist"—to *Dastgah-e Mahour* and *Rast-Panjgah*; and sorrow—"cold and dry"—to *Dastgah-e Shur*. Additionally, the "hot and moist" psychological quality of stability shows a significant association with *Dastgah-e Nava*. This result aligns with the findings of Aslani and Karimi (2018), who noted that individuals with a "hot and moist" temperament show the greatest preference for *Dastgah-e Nava*, those with a "hot and dry" temperament for *Dastgah-e Chahargah*, and those with a "cold and moist" temperament for *Dastgah-e Mahour* [6]. The results demonstrate that, through calculations based on a 17-note system, the intrinsic temperament of each *maqam* and its connection to zodiac signs can be identified. As shown in Table 31, each zodiac sign possesses a distinct temperament, and the intrinsic temperament of a *maqam* may differ from that of its associated zodiac sign. This discrepancy creates unique interactions between the zodiac sign and the *maqam*'s temperament; the *maqam*'s intrinsic temperament influences the psychological states evoked by the melody, while the zodiac sign's temperament exerts additional, compounding effects. When the temperament of a zodiac sign aligns with the inherent temperament of a position, the combined effect on the overall temperament is intensified, leading to a harmony between mental states and temperamental influences.

Table 32. Table of innate temperaments and constellations (zodiac signs) in the seven systems of classical Iranian music.

Mode	Innate temperament	Zodiac sign	zodiac temperament
Homāyun	Warm and moist	Taurus	Cold and dry
Māhūr	Cold and moist	Gemin	Warm and moisti
Rāst-Panjgāh	Cold and moist	Gemini	Warm and moist
Chāhārgāh	Warm and dry	Leo	Warm and dry
Segāh	Warm and moist	Capricorn	Cold and dry
Navā	Warm and moist	Capricorn	Cold and dry
Shūr	Cold and dry	Pisces	Cold and moist

Calculations regarding the zodiac constellations at each stage not only identify temperamental traits but also determine the psychological influences and characteristics being conveyed. For instance, calculations reveal that the core essence of the *Chahargah* mode is influenced by the constellation Leo (the Lion); consequently, its melodies naturally embody qualities such as courage, vitality, and radiant joy.

Results derived from calculating the foundational patterns (core essences) of each mode indicate that—contrary to the belief of some musicians who classify *Nava* as a subset of *Shor*—this mode possesses an independent nature. This is because, if one were to regard *Shor* as the parent scale for *Nava*, the calculation results would fail to align with reality, revealing no meaningful connection between them. Furthermore, the skepticism expressed by some musicians regarding the classification of the *Rast-Panjgah* mode (often viewed as a derivative of *Mahur*) is also noteworthy. Although *Mahur* and *Rast-Panjgah* share a common musical lineage, they evoke distinctly different psychological and emotional responses; this very distinction serves as the primary reason for classifying *Rast-Panjgah* as an independent mode.

Accurately identifying the starting note of each scale is crucial for theoretical analysis and can be determined through numerical calculation rules. In other words, the starting point of the intrinsic scale differs from that of the performance scale. For example, while calculations for the core essence of the *Shor* mode consistently point to the note "C" (Do) across all three calculation tables in this numerical system, from a performance perspective, it can be viewed as originating from the *Shahed* (pivot) note "D" (Re). Therefore, the scale need not necessarily begin with the *shahed* (reference/tonic) note; for instance, in the *Homayoun* *dastgah* (where the *shahed* is A-koron), the starting note of the intrinsic scale is G.

A limitation of the present study is its reliance on three computational tables (two 17-note models and one 24-note "*Manzeli*" model); without these tables, calculating scales containing quarter-tone intervals could lead to errors. Consequently, the accuracy of the results in the 24-note study has been verified, and the findings will be applied to Iranian musical *dastgahs* using the 17-note numerical system.

Interestingly, resolving certain complex scientific problems is possible through simple computational methods. These numerical systems and their associated rules offer a novel approach to understanding theoretical relationships in music therapy, relying on logical and numerical reasoning as well as actual calculations. Since this method employs numbers and calculations to express results, it facilitates the refinement and adjustment of concepts that are otherwise based on subjective or aesthetic preferences.

The reasoning and logic underlying the presented arguments are based on trial-and-error calculations; nevertheless, further field and practical research is recommended to finalize the current project.

Appendices:

I. a- The "natural" sign (♮) cancels the effect of other accidentals and indicates that the note is in its natural state.
b- The "flat" sign (♭) lowers the pitch of the note by a semitone.

c- The "koron" sign (𝄬) lowers the pitch of the note by approximately a quarter-tone (not exactly one-fourth of a whole tone).
II. Innate scale: A scale that, in terms of structure—when compared to other isomorphic or reference scales—possesses a specific sequence of intervals from a particular degree up to the octave. Thus, in a 17-note system, a scale can be written in 17 forms (combinations), but only one of those 17 patterns is recognized as the reference scale.
III. Acquired scale: A scale sharing the same structure as the innate scale but beginning on a different degree; for example, the *Mahur* scale in F, which is played using the interval pattern of the *Mahur* scale in C.
IV. Practical scale: A scale where the performance starting from a specific note determines the character and mood of that *maqam*. For instance, the natural A minor scale is derived from the natural C major scale, yet its practical execution begins on the ascending sixth degree of that same scale.
V. Zodiac constellation and its corresponding planet: Each of the twelve segments of the zodiac (through one of which the sun passes each month, roughly corresponding to our solar months). Each sign of the zodiac has a corresponding 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.
VI. The number twelve signifies a complete cycle or the end of a repetition, and its traces are evident in many things; including the 12 months of the year, the 12 hours of the day, the 12 hours of the night, the 12 modes (*maqams*) in ancient Persian music, the 12 semitones in the intervals of the twelve-note scale, and so forth.
7. At birth, every individual possesses a temperament formed by the innate heat and moisture inherited from their parents; this is known as the "*primary temperament*" or "*innate temperament*." Various factors can influence and alter an individual's temperament [20].

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