On Rhythm:
Definition, Representation, Prediction, and Verification

San DUANMU
University of Michigan
(Draft: Comments welcome)

Department of Linguistics
University of Michigan
440 Lorch Hall
611 Tappan Street
Ann Arbor, MI 48109-1220
USA

谈节奏：定义、结构、预测、验证
端木三
密西根大学

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Abstract   Many discussions of rhythm can be found in the literature, but a general and precise definition of it is yet to be proposed. In addition, with regard to poetry, there is little discussion on how sensitive native speakers are to various factors that contribute to the overall judgment of rhythm, such as riming, 双声 *shuangsheng* 'repeated adjacent onsets', 叠韵 *dieyun* 'repeated adjacent rimes', alliteration (between non-adjacent syllables), or assonance (between non-adjacent syllables), nor has there been any experimental study in support of such discussions. This study offers a precise definition of rhythm, followed by the representation of it, illustrated with some often-cited rhythmic objects. Next, a set of 36 two-line (folk-verse style) modern poems are annotated for (i) riming, (ii) poem structure, (iii) repeated adjacent onsets, (iv) repeated adjacent rimes, (v) alliteration between non-adjacent syllables, and (vi) assonance between non-adjacent syllables, and judgment scores on the overall rhythmicality of the poems are obtained from 13 native speakers. Statistical analyses are then performed. It is found that (i) and (ii) have significant effects on overall rhythmicality, while the effects of (iii)-(vi) are insignificant. Finally, it is shown that the results can be predicted from the representations of various objects of rhythm.

Keywords   rhythm; judgment experiment; poem structure; riming; foot

提要   讨论节奏的文献相当多，可是尚未见到一个简单明确、适合各种节奏类型的定义。文献提到的各种节奏成分（如押韵、双声、叠韵等）对母语人的语感有何影响，有关讨论也很少，而且缺乏实验证据。文章对节奏提出一个简单明确的定义，同时提出节奏的结构表示，并以常见的节奏类型进行演示，然后汇报一个语感实验。语料包括 36 首双行民谣型当代诗歌，每首诗歌都对六种节奏成分进行了标注：1. 押韵、2. 诗歌结构（音步结构）、3. 双声、4. 叠韵、5. 非相邻音节的声母重复（alliteration）、6. 非相邻音节的韵母重复（assonance）。然后，请 13 位母语人对每首诗歌的总体节奏度进行了打分。统计结果显示，节奏成分 1、2 对母语人的节奏感知有显著影响，其他节奏成分无显著影响。文章最后提出，节奏成分的结构可以解释它们影响语感的程度。

关键词   节奏   语感实验   诗歌结构   押韵   音步

1. INTRODUCTION

There are many discussions of rhythm in the literature, by both Western scholars and Chinese scholars. In the West, there is a long tradition of discussing rhythm in music (such as Petersen 2013) and in poetry (often in terms of meter, such as Chatman 1965, Halle and Keyser 1971, Kiparsky 1977, and Hasty 1997). In addition, rhythm has been used to classify languages into two categories: stress-timed rhythm and syllable-timed rhythm (such as Pike 1945 and Abercrombie 1964).

The Chinese term for rhythm is 节-奏 *jie-zou*, where 节 *jie* means 'section' or 'knot' (as in a bamboo) and 奏 *zou* means 'to play' (music). The term is applied to both music and poetry. Indeed, poetry in Chinese is often referred to as 诗-歌 *shi-ge*, literally 'poem-song', because many classic poems used to be songs. A well-known form of Chinese poetry is 律-诗 *lü-shi*, literally 'regulated poem' or 'ruled poem', flourished in the Tang Dynasty (618-907). The rules that govern regulated poems are called 节-律 *jie-lü*, literally 'section rules' or 'rhythm rules'. The term is also used in the study of rhythmic rules in other forms of poetry, and in the study of rhythmic rules in prose (Wu and Zhu 2001). Indeed, some scholars, such as Guo (1926) and Zhu (1943), even believe that rhythm can be found in everything in the universe, such as the alternation of seasons or the undulation of a mountainous landscape.

Since rhythm is used in a diverse range of disciplines and subject matters, one can hardly see a precise and coherent definition of rhythm that applies to all. Therefore, I shall propose such a definition first and compare it with previous ones afterwards. In section 2, I offer a precise definition of rhythm. In section 3, I offer representations of some well-known rhythmic objects in poetry. In section 4, I offer a judgment study of six rhythmic objects in a set of 36 poems in order to find out how much effect each object has on the perceived overall rhythmicality of a poem. In section 5, I discuss the results and show how they can be explained in terms of the representations of the rhythmic objects. In section 6, we consider other definitions of rhythm. In section 7, I offer concluding remarks.

2. DEFINING RHYTHM

To begin, let us consider a simple and typical rhythmic form, which Prince (1983, 47-48) calls 'the perfect grid'. It consists of a sequence of alternating beats, shown in (1), with unspecified starting or ending point. In the simplified representation, S represents a strong beat and W a weak beat. In the grid representation, each x on the lower tier represents a beat, and each x on the upper tier indicates a strong beat.

(1)   A simple rhythmic form: The perfect grid
     a. In simplified representation
       …SWSWSWSW…

     b. In grid representation
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  x   x   x   x
… x x x x x x x x …
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The abstract form can represent many rhythmic objects, such as speech that alternate between stressed and unstressed syllables, drum sounds that alternate between strong and weak beats, the alternation between day and night, and the undulation of peaks and valleys in a landscape.

The perfect grid is not a complete representation though. As Prince (1983) points out, it can be analyzed in two ways, depending on what the unit of repetition is, illustrated in (2).

(2)   Two analyses of the perfect grid
        a.   Repetition of /SW/
             …/SW/SW/SW/SW/…

        b.   Repetition of /WS/
             …S/WS/WS/WS/W…

In the first analysis, the perfect grid is a repetition of /SW/, often called a trochaic foot. In the second analysis, the perfect grid is a repetition of /WS/, often called an iambic foot.

In music it is common to assume that the repetition unit (in this case a 'measure' with a time signature of 2/4) is always /SW/. In addition, Duanmu (2016) has argued that in speech or poetry only trochaic feet are needed. Moreover, as far as our discussion is concerned, the choice between a trochaic foot and an iambic foot is of little consequence. Therefore, in what follows I shall consider trochaic feet only.

The discussion shows that a rhythmic form contains two elements: the unit of repetition, and the nature of the alternation. Therefore, let us define rhythm accordingly, given in (3), where a repetition of X is for X to occur two (or more) times.

(3)   Definition of rhythm
        a.   Rhythm is the repetition of a unit of alternation.
        b.   A unit of alternation consists of two non-identical parts A and B.

It can be seen that when the perfect grid is found in a string of syllables, the string is also a typical poetic line. Therefore, we can represent a poetic line in (4).

(4)   Representation of the perfect grid as a poetic line
        a.   Unit of repetition: a disyllabic trochaic foot
        b.   Parts of alternation: A is a stressed syllable; B is an unstressed syllable.

According to the definition, in order to constitute a repetition of a foot, a poetic line should have at least two feet. In addition, while certain numbers of feet per line are more common than others, there is no theoretical limit on the maximal length of a line.

Similarly, a poem is also a rhythmic object, which is a repetition of a poetic line. Therefore, we can represent a poem in (5).

(5)　　Representation of a poem
　　　　a.　Unit of repetition: a poetic line
　　　　b.　Parts of alternation:　A is a given number of feet; B is a boundary #.

　　　　I hypothesize that a poetic line is determined either phonologically or semantically. Therefore, the boundary # in (5b) represents either the end of an intonation phrase or the end of a semantically coherent unit. According to the definition, in order to constitute a repetition of a poetic line, a poem should have at least two lines, although there is no theoretical limit on the maximal number of lines for a poem.
　　　　In the next section, I shall show representations of other rhythmic objects, commonly discussed in the literature on poetic meter.

3.　REPRESENTING RHYTHMIC OBJECTS IN A POEM
　　　　In this section, we consider six rhythmic objects (or components) in poetry, shown in (6), all of which have been thought to contribute to the overall rhythmicality of a poem.

(6)　　Six rhythmic objects to be discussed
　　　　a.　Riming (riming between two lines)
　　　　b.　双声 *shuangsheng* 'repeated adjacent onsets'
　　　　c.　叠韵 *dieyun* 'repeated adjacent rimes'
　　　　d.　Alliteration (repeated onsets between non-adjacent syllables)
　　　　e.　Assonance (repeated vowels or rimes between non-adjacent syllables)
　　　　f.　Poem

　　　　(6a) is found in both Chinese poetry and English poetry. (6b) and (6c) are frequently discussed in Chinese poetry; they both apply to adjacent syllables only, where 'adjacent' means 'next to each other in a word or compound'.
　　　　(6d) and (6e) are often discussed in English poetry. They can apply to syllables that are either adjacent or not adjacent. Since adjacent syllables are covered by (6b) and (6c) already, we shall use (6d) and (6e) for non-adjacent syllables only.
　　　　According to (6f), a poem should meet its definition in (5), according to which it is a repetition of two (or more) poetic line. Some examples of the rhythmic objects are shown in (7).

(7)　　Examples of rhythmic objects
　　　　a.　Riming (from Alexander Pope, *An Essay On Criticism*)
　　　　　　*True ease in writing comes from art, not ch**ance**,*
　　　　　　*As those move easiest who have learn'd to d**ance**.*
　　　　b.　双声 'repeated adjacent onsets'
　　　　　　彷彿 __f__ang-__f__u 'as if'
　　　　c.　叠韵 'repeated adjacent rimes'
　　　　　　啪啦 p__a__-l__a__ 'a popping sound'

    d. Alliteration (from a nursery rhyme)
       Donald **D**uck
    e. Assonance (from Shakespeare, *Sonnet 1*)
       His t<u>e</u>nder h<u>ei</u>r might b<u>ea</u>r his m<u>e</u>mory
    f. Poem

Line rhythm:	/SW/SW/SW/SW/
Chinese:	/人民/路，/育才/路，/
	/乱窜/就是/黄泉/路！/
Pinyin:	Renmin Lu, Yucai Lu,
	luan-chuan jiu-shi Huangquan Lu!
Gloss:	'Renmin Road, Yucai Road,'
	'Random-stroll it-is Death Road!'

       In (7a), the riming syllables are *chance* and *dance*, whose rimes are identical. Riming syllables can be completely identical as well, with identical onsets and identical rimes, to be discussed later. In (7b), the identical onsets are [f]-[f]. In (7c), the identical rimes are [a]-[a]. In (7d), the identical syllable onsets are [d]-[d], which are not in adjacent syllables. In (7e), the identical main vowels are [e]-[e]-[e]-[e], where in *heir* [eə] and *bear* [beə], the main vowel is the first part of the rime [eə].

       (7f) is a two-line folk verse that advises people to stay home during an epidemic. In the analysis of Duanmu (2004) and Duanmu (2007, chapter 4), each line consists of four /SW/ feet. Therefore, the poem is well formed. In some feet (such as the second in the first line and the fourth in both lines), the weak beat W is realized as the pause (indicated by a punctuation). Other views of foot formation have also been proposed, such as Chen (1979), Chen (2000), and Zhang (2021). However, it can be shown that other proposals of foot formation either have little consequence to our conclusions, or will make wrong predictions.

       With regard to the unit of repetition and the parts of alternation, each rhythmic object has its own representation, shown in Table 1. For riming, A refers to syllables before the last of a line and B refers to the last syllable.

Table 1 Representations of some rhythmic objects

Object	Repetition unit	Alternation parts
Riming	Line	A is a given number of syllables. B is a riming syllable.
Repeated adjacent onsets	Syllable	A is a given onset. B is any rime.
Repeated adjacent rimes	Syllable	A is any onset. B is a given rime.
Consonance	Unspecified	A is a given onset. B is something else.
Assonance	Unspecified	A is something else. B is a given rime.
Poem structure	Line	A is a given number of feet. B is boundary.

In the representations, some units of repetition are a phonological constituent, such as a syllable or a line, but some are not, such as that for consonance and assonance (because the size of the repetition unit is not specified). In addition, some alternation parts have a specified size, such as those for riming, while others do not, such as B for consonance or A for assonance. We shall return to this issue in section 5.

4. A JUDGMENT STUDY

In order to find out how much influence each of the rhythmic object in Table 1 has on the perceived overall rhythmicality of a poem, a judgment study was carried out.

4.1 Material, test sheet, and participants

The original data was a long poem given in Appendix 1, obtained from an internet WeChat site. It contains 38 lines. Based on riming patterns, the poem can be divided into 19 two-line poems.

Since poem 5 does not have the same line length, it is excluded. To change riming and poem structure, 18 new two-line poems were created by a slight change in the second line of each original two-line poem. The resulting 36 poems are shown in Appendix 2.

The poems in Appendix 2 were randomized to create a test sheet, shown in Appendix 3, along with some instructions and sample scores.

From the contents of the poem and the internet site, it can be determined that the original poem was created in Sichuan. Therefore, all participants were native speakers of Sichuan Chinese. There were 13 participants in all. Three were native speakers of Chengdu Chinese. The other 10 were recruited from Chengdu as well.

4.2 Annotation of rhythmic patterns

Each poem is annotated for the six rhythmic objects in Table 1, based on the pronunciation of Sichuan Chinese, which differs from Putonghua mainly in tones and some consonants and vowels. For illustration, annotations for poem 1 are shown in (8) and Table 2, and those for 101 are shown in (9) and Table 3.

(8)   Poem 1 and its Pinyin (in Sichuan Chinese, omitting tones)
        Poem   人民路，育才路，乱窜就是黄泉路！
        Pinyin   Renmin Lu, Yucai Uu, luan-cuan jiu-si Huangquan Lu!
        Gloss: 'Renmin Road, Yucai Road, random-stroll it-is Death Road!'

Table 2 Annotation of rhythmic objects in poem 1

Object	Annotation	Occurrence
Riming	Yes	路-路 lu-lu
Repeated adjacent onsets	0	
Repeated adjacent rimes	1	乱窜 an-an
Consonance	2	路-路 l-l; 乱-路 l-l
Assonance	2	路-路 u-u; 窜-泉 an-an
Poem structure	Yes	(SW)(SW)(SW)(SW) (SW)(SW)(SW)(SW)

(9)   Poem 101 and its Pinyin (in Sichuan Chinese, omitting tones)

Poem   人民路，育才路，乱窜都应该罚款！

Pinyin   Renmin Lu, Yucai Lu, luan-cuan dou yingai fakuan!

Gloss: 'Renmin Road, Yucai Road, random-stroll all should be-fined!'

Table 3 Annotation of rhythmic objects in poem 1

Object	Annotation	Occurrence
Riming	No	*路-款 u-an
Repeated adjacent onsets	0	
Repeated adjacent rimes	1	乱-窜 an-an
Consonance	1	路-路 l-l
Assonance	2	路-路 u-u; 窜-款 an-an
Poem structure	No	(SW)(SW)(SW)(SW) *(SW)(SW)W(SW)

Riming and poem structure are annotated as either yes or no. In contrast, repeated adjacent onsets, repeated adjacent rimes, consonance, and assonance are annotated numerically for the total number of occurrences.

The annotation of riming needs a comment. Riming is often defined as having identical rimes but different onsets (Chao 1923), yet in each of the 18 original poems, the riming syllables are identical. On the other hand, identical syllables do have the same rimes, which constitute the repetition of the rime, and as we shall see below, riming by identical syllable pairs does improve perceived rhythmicality.

As discussed above, consonance only includes cases where relevant syllables are not adjacent. Similarly, assonance only includes cases where relevant syllables are not adjacent.

With regard to poetic structure, both lines of poem 1 have the same foot structure (SW)(SW)(SW)(SW). However, in poem 101, the second line is divided into three pronunciation units, 乱窜/都应该/罚款, whose foot pattern is (SW)(SW)W(SW), if all feet are trochaic and binary. Therefore, poem 101 does not satisfy poem structure, since the second line is not a repetition of the first.

The complete rhythmic annotations of the 36 poems used in the judgment experiment are shown in Appendix 2.

4.3 Errors and exclusions

Of the 19 original poems, poem 5 does not have the same line length. Therefore, it is excluded, along with its counter-part poem 105.

Next, we calculated outlier scores for each of the 36 remaining poems. An outlier score is one that is two standard deviations away from the mean. Two participants were exclude for making 10 outlier scores (out of a total 36 scores). Of the remaining 11 participants, one made 4 outlier scores, one made 3, one made 2, four made 1, and four made none.

4.4 Results

We discuss riming and poem structure first, repeated adjacent onsets next, and finally repeated adjacent rimes, consonance, and assonance.

The basic statistics of riming and poem structure are shown in Table 4. The T-Test results for the patterns are shown in Table 5.

Table 4 Basic statistics on riming and poem structure

Pattern	Observations	Variance	Mean
YY (riming=yes, poem=yes)	184	0.34	4.73
YN (riming=yes, poem=no)	22	1.84	2.86
NY (riming=no, poem=yes)	119	2.31	2.31
NN (riming=no, poem=no)	41	0.41	1.49

Table 5 T-Test results for the patterns in Table 4
(Unpaired, two-tail, assuming unequal variances; *** = <0.0001)

	YY	YN	NY
YN	***		
NY	***	--	
NN	***	***	***

Table 4 shows that, between YY and YN, the lack of poem structure reduces the mean rhythmicality score by nearly 2 points, and between YY and NY, the lack of riming reduces the mean score by more than 2 points. T-Test results in Table 5 show that all patterns in Table 4 are highly significantly different from each other, except NY and YN, whose difference is not statistically different. It can be shown that whether outlier scores among the 11 participants are excluded has no effect on the results.

Next we consider the effect of repeated adjacent onsets. In each of the 36 poems, repeated adjacent onsets occurs at most once. Therefore, we used T-Tests (unpaired, assuming unequal variances) to compare the mean rhythmicality scores of poems with repeated adjacent onsets and those without. In addition, to exclude the effects of riming and poem structure, we examine the repeated adjacent onsets effect separately in the two patterns that have the most observations: first in the YY pattern, shown in Table 6, and then in the NY pattern, shown in Table 7. YN and NN patterns do not have many observations and are not considered.

Table 6 Effect of 'repeated adjacent onsets' (RAO) in the pattern YY

	RAO =0	RAO =1
Mean	4.666667	4.842857
Variance	0.418879	0.19234
Observations	114	70
df	180	
t Stat	-2.19859	
P(T<=t) two-tail	0.029182	
t Critical two-tail	2.603418	

Table 7 Effect of 'repeated adjacent onsets' (RAO) in the pattern NY

	RAO=0	RAO=1
Mean	2.315789	2.302326
Variance	1.178947	1.596899
Observations	76	43
df	77	
t Stat	0.058678	
P(T<=t) two-tail	0.953361	
t Critical two-tail	2.641198	

In Table 6, the occurrence of repeated adjacent onsets reduces the mean rhythmicality score slightly, but the reduction is not statistically significant. In Table 7, repeated adjacent onsets shows no significant statistical effect either.

Finally, let us consider the effects of repeated adjacent rimes, consonance, and assonance, all of which can occur multiple times. Therefore, for each factor, we consider the correlation between the number of occurrences and the rhythmicality scores. The results in the YY pattern are shown in Table 8. The results in the NY pattern are shown in Table 9.

Table 8 Correlation coefficients between rhythmicality and each of three factors
(In the YY pattern, N = 184)

Factor	Correlation
Repeated adjacent rimes	0.146785
Consonance	-0.01722
Assonance	0.066501

Table 9 Correlation coefficients between rhythmicality and each of three factors
(In the NY pattern, N = 119)

Factor	Correlation
Repeated adjacent rimes	-0.00079
Consonance	0.139921
Assonance	0.152131

Given the standard interpretation that if the absolute value of the correlation coefficient is less than 0.3, the correlation is nonexistent or negligible, we conclude that none of the three factors (repeated adjacent rimes, consonance, or assonance) has an effect on the perceived rhythmicality of a poem.

4.5 Summary

Our study shows that riming and poem structure has significant effects on the perceived rhythmicality of a poem, while repeated adjacent onsets, repeated adjacent rimes, consonance, and assonance do not.

5. EXPLAINING THE EXPERIMENTAL RESULTS

In this section we consider whether the representation of a rhythmic object can help explain its effect (of lack of it) on the perceived rhythmicality of a poem. The representations of the six rhythmic objects are given in Table 1, repeated in Table 10.

Table 10 Representations of some rhythmic objects

Object	Repetition unit	Alternation parts
Riming	Line	A is a given number of syllables. B is a riming syllable.
Repeated adjacent onsets	Syllable	A is a given onset. B is any rime.
Repeated adjacent rimes	Syllable	A is any onset. B is a given rime.
Consonance	Unspecified	A is a given onset. B is something else.
Assonance	Unspecified	A is something else. B is a given rime.
Poem structure	Line	A is a given number of feet. B is boundary.

We can see, first, that the repetition unit for consonance and assonance are unspecified, while those for other objects are constant. Therefore, consonance and assonance do not show the repetition of a phonological category, such as a syllable, a foot, or a line. Therefore, consonance and assonance may not be rhythmic objects, strictly speaking.

Next we consider the units of alternation parts. It can be seen that, for repeated adjacent onsets and repeated adjacent rimes, the alternation parts are either an onset or a rime, while in riming and poem structure, the alternation part are either syllables, feet, or a boundary (of an intonation phrase). If alternating parts cannot be smaller than a syllable, then we can correctly predicts that consonance and assonance have no effects on perceived rhythmicality either.

6. OTHER DEFINITIONS OF RHYTHM

In this section we consider other definitions of rhythm. For lack of space, we sample just a few below in order to show a wide range of views.

(10)   Guo (1926, 8) on rhythm (English translation by the present author):
宇宙間的事物沒有一樣是沒有節奏的：譬如寒往則暑來，暑往則寒來，寒暑相推，四時代序，這便是時令上的節奏；又譬如高而爲山陵，低而爲溪谷，陵谷相間，嶺脈蜿蜒，這便是地殻上的節奏。宇宙內的東西沒有一樣是死的，就因為都有一種節奏（可以說就是生命）在裡面流貫着的。

None of the things in the universe is without rhythm: For example, when the cold season ends, the hot season begins, and vice versa; such alternation of seasons is the rhythm of time. Similarly, the landscape consists of high mountains and low valleys, and such alternation stretches out, which is the rhythm of the earth's surface. Nothing is dead in the universe, because there is a rhythm (or life) flowing in everything.

(11)   Zhu (1943, 155) on rhythm (English translation by the present author):
节奏是宇宙中自然现象的一个基本原则…寒暑昼夜的来往，新陈的代谢，雌雄的匹配，风波的起伏，山川的交错，数量的乘除消长，以至于玄理方面反正的对称，历史方面兴亡隆替的循环，都有一个节奏的道理在里面。

Rhythm is a basic principle among natural phenomena in the universe…The alternation between cold and hot seasons and between day and night, the replacement of old cells by new cells in organisms, the mating between female and male, the waves of wind and water, the undulation of mountain peaks and valleys, the opposite effects of multiplying and dividing a number, the pairing between the positive and the negative, and the alternation between rise and fall of cultures in history, are all due to their internal rhythm.

(12)   Feng and Shi (2021, 42) distinguish rhythm in language and rhythm in nature:
Rhythm in language (节律 *jielü*): The repetition unit contains an alternation.
Rhythm in nature (节奏 *jiezou*): The repetition unit contains no alternation.

(13)   Zhang (2021) on 'meter' vs. 'rhythm':
节律 *jielü* 'meter' is the template (or type) of a poem.
节奏 *jiezou* 'rhythm' is the phonetic property of a linguistic structure.

(14)   Wu (1991, 15) on rhythm (English translation by the present author):
我们对语言节奏是否可概括为：语音的徐疾、高低、长短、轻重及音色的异同，在一定时间内有规律地相间交替回环往复的组合形式。

We may offer a definition of rhythm in language as follows: It refers to a form in which a variation in speed, pitch levels, length, stress, or voice quality of speech occurs, where the variation is repeated regularly in a given section of time.

(15)   Pike (1945, 35) on rhythmic types of language:
        Syllable-times languages:
        The duration of every syllable is more or less equal.

        Stress-timed languages:
        The duration between two stressed syllables are more or less equal, regardless how many
        syllables there are in between.

(16)   Hasty (1997, 3) on rhythm:
        Everything the word "rhythm" implies can be found in music. Among the attributes of
        rhythm we might include continuity or flow, articulation, regularity, proportion,
        repetition, pattern, alluring form or shape, expressive gesture, animation, and motion (or
        at least the semblance of motion). Indeed, so intimate is the connection of the rhythmic
        and the musical, we could perhaps most concisely and ecumenically define music as the
        rhythmization of sound (thus, the "musicality" of speech or verse).

(17)   Petersen (2013, 7) on rhythmic types of language:
        A comprehensive theory of the temporal relation in a music composition is overdue, one
        that is ready to recognize all sound signals as producing duration and consequently also
        rhythm.

Guo (1926) and Zhu (1943) probably mean that humans can see rhythm in many things in the universe (instead of everything having rhythm independent of human perception). Their descriptions of rhythm also similar to the present one, in that rhythm is made of alternation and repetition.

Feng and Shi (2021) are probably right to propose that there is a difference between rhythm in speech and rhythm in other things. However, the difference does not seem to lie in the lack of alternation in non-speech rhythms. For example, there is an alternation between beat and pause in drum beats, and there is an alternation between day and night in a daily cycle. We can, instead, distinguish speech rhythm and other rhythms by the units of alternation: In speech, the alternating units are phonological categories, such as syllables and feet, whereas in non-speech rhythms the alternation units are not phonological categories.

Zhang (2021) also offers different definitions for 节律 *jielü* and 节奏 *jiezou*. The former refers to meter and the latter refers to the phonetic realization of a linguistic structure. In this regard, his 节律 *jielü* is similar to what Kiparsky (1975) calls the 'template' of a poem and his 节奏 *jiezou* is similar to what Kiparsky (1975) calls the stress pattern of a poetic line that is generated by metrical rules. Although Zhang's 节奏 *jiezou* is 'rhythm' in Chinese, his definition of the term is clearly not quite the same as the present definition of rhythm.

Wu (1991) reviews a number of definitions of rhythm and offers (15) for speech, which is quite similar to ours, although she does not offer separate representations of rhythmic objects.

Pike (1945) considers there to be two rhythmic types in language: (i) stress-timed and (ii) syllable timed. In (i), the repetition unit is a stress unit (a stressed syllable plus any unstressed

syllables after it), and the alternation is between stressed and unstressed syllables. In (ii), the repetition unit is a syllable, but it is unclear what the alternation is.

Hasty (1997) takes a narrower view of rhythm. He believes that rhythm is best seen in music, but he does not emphasize the two essential properties of rhythm, namely, alternation and repetition. Petersen (2013, 7) also discusses rhythm in music. He proposes that rhythm is made of many components, but he does not emphasize alternation or repetition either.

It can be seen that two central properties, alternation and repetition of alternation, are found in most definitions, directly or indirectly, in support of the present general definition in (3). However, no previous study offered a formal way to represent a rhythmic object. Finally, no previous study makes predictions on whether a rhythmic object (or component) has any effect on perceived rhythmicality, nor experimental verifications of the predictions.

7. CONCLUDING REMARKS

I have proposed that a general and precise definition of rhythm is possible, whether it is in speech or not. In addition, I have offered a judgment experiment on perceived rhythmicality of Chinese poems. The results show that some commonly discussed rhythmic objects (or components), in particular riming and poem structure, have large and significant effects on perceived rhythmicality, while other commonly discussed rhythmic objects, in particular 双声 *shuangsheng* 'repeated adjacent onsets', 叠韵 *dieyun* 'repeated adjacent rimes', consonance, and assonance contribute little to perceived rhythmicality. Moreover, I have shown that, as far as poetry is concerned, the effect of a rhythmic object on perceived rhythmicality can be explained by the formal representation of the rhythmic object.

I have not considered all rhythmic objects that have been proposed in the literature, such as the requirement for tonal alternations in Chinese regulated verse. Nor have I discussed how to analyze layered stress patterns, such as /1 3 2 3/1 3 2 3/... in some eight-beat poems (such as the one discussed in Hayes 1995, 26-27), where 1 is stronger than 2, and 2 is stronger than 3. However, I hope this study offers new possibilities in how to address such problems.

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Appendix 1: An original poem made of 19 two-line pairs (from an internet WeChat group)

Pairs	Line 1	Line 2
1	人民路，育才路，	乱窜就是黄泉路！
2	大廊桥，小廊桥，	出门就是奈何桥，
3	百步街，中大街，	不想中毒莫上街！
4	大公园，小公园，	直接送到青松园！
5	熊猫大道，茶马古道，	呆在家里是正道！
6	金鸡关，飞仙关，	大家不闯鬼门关！
7	官二代，富二代，	出门都是毒二代！
8	宅初一，宅十五，	不宅就是二百五！
9	悬空寺，金凤寺，	抗战疫情不怕事。
10	外地人，本地人，	不戴口罩是坏人。
11	志愿者，支援者，	他们都是战斗者！
12	周公山，蒙顶山，	走在前面钟南山！
13	这个军，那个军，	最终要靠人民军！
14	矿泉水，自来水，	莫让医生流泪水！
15	亲戚们，邻居们，	解封以后看您们！
16	挞挞面，刀削面，	瘟疫过了再见面！
17	莫轻心，莫灰心，	战疫打胜才放心。
18	比赛赢，赌博赢，	战胜病毒算真赢。
19	今不喝，明不喝，	最后胜利咱再喝！

Appendix 2: 36 two-line poems used in the experiment, along with their annotations in riming (R), poem structure (PS), repeated adjacent onsets (RAO), repeated adjacent rimes (RAR), consonance (cons.), and assonance (ass.).

Poem	Line 1	Line 2	R	PS	RAO	RAR	Con.	Ass.
1	人民路，育才路，	乱窜就是黄泉路！	y	y	0	1	2	2
2	大廊桥，小廊桥，	出门就是奈何桥，	y	y	0	0	2	3
3	百步街，中大街，	不想中毒莫上街！	y	y	1	0	1	3
4	大公园，小公园，	直接送到青松园！	y	y	0	0	3	3
6	金鸡关，飞仙关，	大家不闯鬼门关！	y	y	1	1	2	2
7	官二代，富二代，	出门都是毒二代！	y	y	0	0	4	3
8	宅初一，宅十五，	不宅就是二百五！	y	y	0	0	2	3
9	悬空寺，金凤寺，	抗战疫情不怕事。	y	y	0	0	1	2
10	外地人，本地人，	不戴口罩是坏人。	y	y	0	0	2	4
11	志愿者，支援者，	他们都是战斗者！	y	y	0	0	5	4
12	周公山，蒙顶山，	走在前面钟南山！	y	y	1	2	1	4
13	这个军，那个军，	最终要靠人民军！	y	y	1	1	2	2
14	矿泉水，自来水，	莫让医生流泪水！	y	y	1	0	2	1
15	亲戚们，邻居们，	解封以后看您们！	y	y	1	0	1	1
16	挞挞面，刀削面，	瘟疫过了再见面！	y	y	1	3	1	1
17	莫轻心，莫灰心，	战疫打胜才放心。	y	y	0	1	2	2
18	比赛赢，赌博赢，	战胜病毒算真赢。	y	y	0	0	3	4
19	今不喝，明不喝，	最后胜利咱再喝！	y	y	0	0	4	3
101	人民路，育才路，	乱窜都应该罚款！	n	n	0	1	1	2
102	大廊桥，小廊桥，	要出去都不应该。	n	n	0	0	3	4
103	百步街，中大街，	很可能都有病毒！	n	n	1	1	2	2
104	大公园，小公园，	下来就是火葬场！	n	y	0	0	2	3
106	金鸡关，飞仙关，	什么关都不要去！	n	y	1	0	1	2
107	官二代，富二代，	谁出门都不允许！	y	n	0	0	2	3
108	宅初一，宅十五，	不宅就是傻瓜蛋！	n	y	0	1	2	2
109	悬空寺，金凤寺，	抗疫期间都别去。	n	y	0	1	2	2
110	外地人，本地人，	谁不戴口罩就罚。	n	n	0	0	2	3
111	志愿者，支援者，	他们都是真英雄！	n	y	0	0	3	4
112	周公山，蒙顶山，	指路的人钟南山！	y	n	0	1	2	2
113	这个军，那个军，	最终都要靠人民！	n	y	1	0	2	3
114	矿泉水，自来水，	莫让医生泪水流！	n	y	0	1	2	1
115	亲戚们，邻居们，	解封以后再见面！	n	y	1	1	2	2
116	挞挞面，刀削面，	瘟疫过了再去吃！	n	y	1	2	1	1
117	莫轻心，莫灰心，	抗疫一定能成功。	n	y	0	1	3	3
119	今不喝，明不喝，	不到胜利不聚会！	n	y	0	0	3	4

Appendix 3: Test sheet

说明：
- 下面的顺口溜，每个由两行组成。
- 请根据你的语感，给每个顺口溜的节奏打分，从 1=不好到 5=很好，选一个最恰当的得分值。
- 顺口溜的意义可以忽略，只要求注重节奏。
- 五个例子的得分只是示范。你的语感不必跟示范得分完全一致。

例	顺口溜	节奏选择	得分
1	张老三，我问你，你的家乡在哪里?	不好 1—2—3—4—5 很好	5
2	张老三，我问你，你的家乡在何处?	不好 1—2—3—4—5 很好	4
3	张老三，我问你，你们的家在哪里?	不好 1—2—3—4—5 很好	3
4	张老三，我问你，你们的家在何处?	不好 1—2—3—4—5 很好	2
5	张老三，我问你，你的家乡在什么地方?	不好 1—2—3—4—5 很好	1
序	顺口溜	节奏选择	得分
1	亲戚们，邻居们，解封以后看您们!	不好 1—2—3—4—5 很好	
2	金鸡关，飞仙关，什么关都不要去!	不好 1—2—3—4—5 很好	
3	挞挞面，刀削面，瘟疫过了再见面!	不好 1—2—3—4—5 很好	
4	百步街，中大街，很可能都有病毒!	不好 1—2—3—4—5 很好	
5	今不喝，明不喝，最后胜利咱再喝!	不好 1—2—3—4—5 很好	
6	百步街，中大街，不想中毒莫上街!	不好 1—2—3—4—5 很好	
7	外地人，本地人，不戴口罩是坏人。	不好 1—2—3—4—5 很好	
8	大廊桥，小廊桥，要出去都不应该。	不好 1—2—3—4—5 很好	
9	悬空寺，金凤寺，抗疫期间都别去。	不好 1—2—3—4—5 很好	
10	大廊桥，小廊桥，出门就是奈何桥，	不好 1—2—3—4—5 很好	
...	...	...	
36	莫轻心，莫灰心，战疫打胜才放心。	不好 1—2—3—4—5 很好	