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In the Beginning Was Music! Computational Analysis of the Hymn to Nikkal and the Rig Veda Reveals Musical Connection Between Distant Bronze Age Societies

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Abstract: The Hymn to Nikkal is the oldest surviving musical text with well-preserved musical notation, although the language in which it is written has remained almost entirely unintelligible. By comparison, the Rig Veda is the oldest complete collection of verses, written in one of the best-understood ancient languages. However, these approximately 20,000 verses have been passed down to us without musical notation. Coincidentally, the Hymn to Nikkal and the Vedas stem from the same Bronze Age period—or was the connection between them deeper than mere contemporaneity? The present article performs a systematic analysis of the rhythm and cadences present in the hymn and the Vedas and demonstrates that they are closely related. The Hymn to Nikkal can therefore be interpreted as an echo of the tradition of the Rig Veda, from which it receives and on which it helps shed new light for modern-day audiences. Furthermore, the musical connection between hymn and Vedas also provides evidence for the existence of a significant cultural connection between distant Bronze Age societies. A cultural connection between these societies has long been expected and is now finally documented through the most volatile of sources possible: music. Music has wings; it disappears quickly, yet it also easily spreads across the globe.

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Introduction

The kingdom of Mitanni was a Bronze Age society of the Near East that has left two immensely valuable gifts. The first gift is the earliest archaeological evidence for the existence of the Vedic language and culture (Novák, 2007; Fournet, 2010).

This first gift is truly important because of both the significance and elusiveness of the Vedic language. On one hand, Vedic is one of the best-understood Indo-European languages of the Bronze Age, having spearheaded the initial development of historical linguistics (Klein and Tucker, 2014; Geldner, 1951). On the other hand, Vedic is primarily known due to oral traditions. It has remained unwritten for an unknown number of centuries. Without the evidence from Mitanni, one would be at a loss, relying almost entirely on guesswork to determine when the language was spoken (Spinney, 2025).

The evidence from Mitanni is not just valuable as archeological material. The Vedic words that have been recorded fall in a narrow list of three categories: terms related to horsemanship, names of Vedic gods, and Vedic names adopted by local rulers (Novák, 2007; Spinney, 2025; Gernot, 1989). Coincidentally, the name „Mitanni" itself—or „Maitanni", as it appears in early sources—may be a testimony to ancient connections between the Hurrians and the ancestors of Vedic-speaking peoples. „Maitanni" is derived from the Indo-European word root *maita- „to unite" (Fournet, 2010). If this is true, it appears that these United People or United States of the bronze age (depending on whose interpretation is followed) did indeed unite multiple cultures: the majority of the population was

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Hurrian, but there were also political, religious, and technological ties to Vedic-speaking peoples and their ancestors.

Given that this evidence from Mitanni is the oldest archaeological evidence for the existence of the Vedic language, historians have speculated about the nature of the connection, especially between India and Mitanni. Suddenly, many questions emerged that could not be answered: Were Mitanni's rulers ethnically Vedic, or did they just bear Vedic names? Were Mitanni's horsemen ethnically Vedic, or did they just use Vedic loanwords? The answers are lost to history. Who could really know? (Spinney, 2025)

The second gift is more generally linked to Hurrian culture beyond Mitanni, but it is all the more delightful. It is the oldest preserved musical composition. It was not found in Mitanni's capital Washukanni or in another predominantly Hurrian city, such as Urkesh, but in Ugarit, on the east coast of the Mediterranean (Krispijn, 1990; West, 1994; Thiel, 1977; Smith and Kilmer, 2000).

The composition is a Hymn to Nikkal, part of a larger Hurrian musical library written on clay tablets, of which this hymn alone has been preserved in its entirety. Attempts to decipher the notation proved successful in the 20th century (Hagel, 2005). The composition is two-voiced, and, perhaps not unexpectedly, much shorter than the Hurrian lyrics (Krispijn, 1990; Hagel, 2005; Krispijn, 2002). To confidently study this music, and what it reveals about the people who sang it and their united Hurrian, Vedic, and Near Eastern context, we must begin by mapping the lyrics onto the musical notation. Once this is done, we can perform and listen to this composition written down by a Semitic scribe on the Mediterranean in a barely understood Bronze Age language of the Caucasus, and with rhythmic patterns that may reveal something quite remarkable about music in the Bronze Age.

Results

The analysis of the Hymn to Nikkal given in the present article begins by mapping the lyrics onto the music. Many musical compositions have less music than lyrics, repeating the music over multiple stanzas (Duckworth, 2012). This arrangement satisfies the human need for novelty with minimal effort in composition, while also enhancing the chances that the music, repeated often enough, is memorized with just those words that seem to most matter in the moment when it is performed. Perhaps for this reason, strophic musical arrangements are found in most cultures from Antiquity to the present day.

In the case of the Hymn to Nikkal, it is very likely that a strophic arrangement was chosen; it can make for an exact mapping of the lyrics onto the music. Each syllable in the lyrics is thus mapped exactly onto one musical note. The resulting music-with-lyrics arrangement is performed in the attached audio file (Supplemental Material).

Admittedly, there are many instances in which the mapping of the Hurrian lyrics onto the music is still uncertain. However, these uncertainties arise entirely due to missing syllables in the lyrics which has been less well preserved than the music (having written on the back side of the tablet), or due to linguistic uncertainty. By far the largest linguistic uncertainty is what exact phonetic values are represented by sequences of two consecutive vowels in the cuneiform syllabary used by the scribe.

Ugarit, the city where the clay tablet with the Hymn to Nikkal was found, was a melting pot of cultures, boasting its own alphabet as far back as the 14th century BCE (National Museum of Damaskus, 2025). Unfortunately, our scribe—Ammurabi by name—did not use this first cuneiform alphabet, but the standard syllabary, developed much earlier, and not for Hurrian (Krispijn, 2002). The problem is how spoken syllables are translated into written syllables. For example the Hurrian text „we-ša-al ta-ti-ib ti-ši-ja" [perhaps „she loves them with her heart" (Krispijn, 2002)] and „ka-li-ta-ni-il Ni-ka-la" [perhaps „hear this, Nikkal"], are likely seven true syllables, although nine and eight are written. A more difficult problem is posed by sequences of two or even three vowels as in „zi-u-e" [meaning unknown], which may or may not have been spoken as one, two, or three syllables in Hurrian. As a rule of thumb, we expect to see slightly more syllables written than pronounced. The problem with this type of orthography is that it must first be interpreted, and every falsely accepted

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syllable offsets all that follow in the same verse. Luckily, contracting co-occurring vowels into one always yields the expected text length. In this way, the lyrics can be mapped onto the music. In principle, it is not necessary to perform this mapping only to study the rhythm. The mapping is provided here only for the sake of completeness.

Now that we have mapped the lyrics onto the music, we can continue without hesitation to focus on the relationship between music and rhythm. The music is written down in two voices, as a sequence of dyads (Hagel, 2005 calls them dichords). Technically, „dyads" are chords composed of two tones, as opposed to „triads" which consist of three tones. Dyads could have been played, for example, on double pipes commonly known under the Greek name „auloi" or on harps, where two strings are frequently played simultaneously, one with each hand. In the Hurrian musical notation, following the dyads are numeric values (Hagel, 2005). Initially, historians interpreted these numbers as some kind of repetition, playing the dyads repeatedly. The aim of this rather unnatural interpretation was to lengthen the music and make it fit the length of the lyrics, but this attempt proved unsuccessful (Krispijn, 2002). In parallel, the suspicion arose that the numeric values after each dyad encoded its duration, rather than repetition (Hagel, 2005). An overlooked fact that speaks for this interpretation is that the values 2 and 4 are more frequent than expected, while 3 and 5 are more rare (Hagel, 2005 has a table that visualizes this, but doesn't discuss it). Translated to modern-day notation, this means that half and full tones are more frequent than extended half and extended full tones. This still holds true today, and it appears to have been the case in Hurrian music as well. Additionally, the interpretation of the numbers as tonal duration allows mapping the lyrics precisely onto the music, as has already been established earlier in this article. Last but not least, now that we have durations, there is a rhythm—and not only is there a rhythm, which is essential to most music, but this rhythm is stunningly beautiful when performed… The rhythmical patterns don't seem at all random, but strike a deep chord with audiences.

Listening to this music, one can only wonder: Where does this beauty come from? The rhythm seems strangely familiar. How does this sense of familiarity arise, in a musical composition that is more than 3,000 years old? The repeated cadence-like rhythmic patterns seem particularly appealing.

Cadences in music mostly refer to harmonic sequences that mark the end of a compositional entity (Randel, 1999). A simple example is the sequence Sol—La—Si—Do / G-A-B-C in European classical music. People easily recognize this sequence as a true end of a composition in Do major / C major. Next to such authentic cadences that clearly mark the end of a composition, there are also half cadences that suggest only a partial end. Cadences help organize musical thought, signaling either closure or continuation. It is possible although less common for a song to end without a cadence, or else it leaves the minds of the audiences erring, searching for a true end.

In addition, harmonic cadences, there are also rhythmic cadences. These are rhythmic patterns that mark the end of a rhythmic unit—the end of a verse, for example (Van Nooten and Holland, 1995). Rhythmic cadences can be studied across both the Hymn to Nikkal and the Rig Veda because the rhythms are known in both cases. Before we do that, let us briefly review what cadences are, in a broader sense. It is helpful to have a broad understanding of the matter before addressing 3000-year-old compositions.

Cadences are not unique in music. Closely related to music, they are the equivalent of rhymes in poetry. In a way, musical cadences are harmonic rhymes, and rhythmical cadences are rhythmic rhymes (Zhirmunsky and Hoffmann, 2013). They give audiences a sense of familiarity and comprehension. Indeed, even in daily life, when people say that something "has no rhyme or reason" or "doesn't rhyme," they often use these words as an idiom to indicate that something isn't right (Merriam-Webster Dictionary, 2025). Perhaps rhymes and cadences thus reflect a deeper human need for harmony and comprehension. People can have complex thoughts, but one often feels reassured when these thoughts always lead to the same conclusion. They rhyme.

An equivalent of cadences and rhymes also exists in scientific thinking. In particular, any validation process requires that the same result is obtained a second time through an independent path. Formally speaking, the result then works like a rhyme, reappearing at the end of a new,

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independent statement. For example, performing an algorithm A on training and testing data should yield the same accuracy Acc. This means that the results converge and the training is successful (Hastie et al. 2009). One can state:

$$A(data\_train) = Acc$$

$$A(data\_test) = Acc$$

Here, an algorithm A is trained on a training dataset *data_train*, after which it is tested on an independent testing dataset *data_test*. For the training to be successful, the accuracy *Acc* must become approximately the same (or at least converge rather than diverge). Thus, the accuracy in the mathematical statement performs roughly the same formal role that a rhyme performs in verses. It reconfirms an idea.

Similarly, approximation works like a rhyme. Archimedes, for example, calculated π by proceeding with two independent constructions which both lead up to π, estimating the lower and upper bounds of this number (Archimedes, 2010). His approach can be summarized for a circle with diameter = 1 and inscribed and circumscribed n-edged polygons, as follows:

(for $n \gg 1$) (perimeter of inscribed n-gon) $= \pi$
(for $n \gg 1$) (perimeter of circumscribed n-gon) $= \pi$

The recurring theme in all of these cadences, rhymes, and validation and approximation approaches is that the person exploring them takes different, sometimes surprising paths, while always returning to the same, reassuring final conclusion. In this sense, cadences are literally as well as formally "conclusions". It is good to follow complex chains of thought, but, at the end of the day, one would like to see the reassuring presence of a foreseeable, unchanging conclusion.

What then, do these considerations have to say about cadences? Good cadences have to be reassuring, clearly recognizable endings, and not chance encounters. Otherwise, someone could say, „True, the two independent paths you have taken yield the same result, but just by chance!" In mathematics, the concept of statistical relevance was developed to settle exactly that question: is a result obtained by chance? Technically, low α values significantly, low probability for chance encounter, and, therefore, high statistical significance (Moore et al. 2016). We will utilize statistical significance to identify just how unique cadences are in Vedic poetry. It turns out, they are not mistakable for common chance encounters, as will be shown. Instead, they are good, recognizable, and reassuring verse conclusions.

To summarize, it is good if a cadence is clearly recognizable, or otherwise one would feel like Ulysses come home after ten years of adventures, unable to recognize his dear Ithaka (Homer, 1995)! It is good to set sail, but in the end, no port is as beautiful as that of one's own motherland (Hatzidakis, 1960). In the end, one has to "drive the point home," as English speakers sometimes say (Sinclair, 2004). Rhymes and cadences are an artistic form that satisfies this human desire for familiarity and recognizable order.

Many musical cultures have discovered cadences, beginning with the Indian culture that brought forth the Vedas. Notably, verses in the Vedas can have many different openings, but the number of different cadences is much smaller. For example, the most popular verse form of the Rig Veda—the Triṣṭubh—has at least five common opening patterns but virtually only one typical ending. This cadence marks the ends of more than 95% of a total of 16450 Triṣṭubh verses in the Rig Veda, and it is a rhythmic pattern that makes for a clear and reassuring finale for each verse that it crowns (Van Nooten and Holland, 1995). Stunningly, a very similar cadence returns in ancient Greek and Roman poetry (West, 1982). Perhaps it was passed on to Vedic Indians, Hellenes, and Romans together with their language from shared Proto-Indo-European ancestry (White, 1909)? If so, did the cadence remain unchanged over the millennia? The same shared ancestry would also have passed down the melodic accent in its language, due to which melodies go down in pitch after word accents (West, 1992; Edgerton, 1952). Or were cadence and falling melodic lines simply beautiful, and people

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across language borders passed them back and forth between them, again and again, simply because of the delight they experienced?

Roughly the same cadence together with falling melodic lines is also found in the Hymn to Nikkal. To expand on this point, the present article performed a computational evaluation. The exact cadences extracted from the Hymn to Nikkal in their full length were searched amid verse endings in the Rig Veda, and this search returned hundreds of exact matches. To demonstrate that these numbers are statistically significant, the computational evaluation contains a comparative study against a set of 1,000 Rig Veda versions, in which word order was randomly changed. A computer code thus generated 1,000 permutations of the Rig Veda. These permutations created without care for the rhythm reveal that the rhythmic patterns of the Hymn to Nikkal and the Rig Veda are not a chance encounter. Indeed, the rhythmic patters of the Hymn to Nikkal are frequent in the real Rig Veda, while being significantly more rare among random textual permutations. As a matter of fact, all cadences found in the Hymn to Nikkal are found with unequalled frequency in the real Rig Veda, while they are never found to a same extent in any of the 1,000 randomly altered Rig Vedas. Thus, all rhythmic cadences that have been found in the Hymn to Nikkal connect it with the Rig Veda, interlinking the two musical cultures (Supplemental Data).

Statistically speaking, the link is by no means a randomly generated chance encounter. The α value, which denotes the probability that the cadences are a randomly generated chance encounter, is always extremely low in our analysis, below statistically detectable levels. With 1,000 permutations created for the Rig Veda, α is calculated for each of the analyzed cadences to be below 1/1000. This means that the chance of finding each of these cadences by circumstance is extremely low. One does not find the same frequency for any of the studied cadences, even in a thousand or many more permutations of the Rig Veda.

As a rule of thumb, the individual α values of multiple independent tests can be multiplied to estimate a joint α value for all tests together. In our case, this would give $1/1000^3$ for the three cadences that make up the Hymn to Nikkal—a value of one in a billion. Thus, it can be concluded that the match is excellent. The cadences of the Hymn to Nikkal are typical Rig Veda cadences that did not make it into the Rig Veda by chance. The ancient Vedic people would have had to write a billion or more Rig Vedas if they had to generate the rhythms of the Hymn to Nikkal without favoring them. Naturally, they wrote only one Rig Veda, and they very much favored the rhythms also found in the Hymn to Nikkal. The rhythmic signature of the Hymn to Nikkal connects it to the Rig Veda, which has this rhythmic signature, as well. In other words, the Hymn to Nikkal "rhymes", rhythmically speaking, with the Rig Veda.

Discussion

The Hymn to Nikkal bears a distant influence, linking distant Bronze Age societies. These societies were also connected through politics, religion, and technology. Which connection, then, was the first? Is it possible that music and art connect the world before speech, money, religion, or politics? Perhaps the role of music is underestimated because archeologists never get to hear musical compositions performed by prehistoric people…

The Hymn to Nikkal reveals that music both spreads and blends in easily, linking distant motives and themes. As a matter of fact, the hymn reflects an intricate web of connections. The clay tablet on which the hymn was inscribed was found in Ugarit. The musical notation is Hurrian, but this notation is derived from Near Eastern musical notation. Also, Nikkal is a Near Eastern goddess, venerated by the Akkadians already a millennium earlier, then as Ningal. Thus, there are musical connections across a broad range of cultures. In music, everything seems interconnected. Was there—just perhaps—a global musical culture already in the Bronze Age?

To answer this question, more evidence will be needed, and direct evidence is unlikely to be found, considering the fleeting nature of music. However, it may be important to remember that competing cultures experience competitive exclusion. Good ideas spread fast and conquer the world. They have wings. A global musical culture in which some musical ideas were disseminated and came

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to dominate could have easily established itself. Assuming that there are basic means of communication, and assuming that some musical ideas have more appeal than others, competitive exclusion immediately emerges, and with it, a cohesive musical culture that covers the globe. Avoiding competitive exclusion requires nonlinear mechanisms of diversification which are not always easy to develop (Baciu, 2020, 2023). Perhaps then, it is fair to say that, in the beginning, the world was united by Art.

Megalomaniac politicians for whom the Earth was too small to offer enough resources have sometimes tried to legitimize military conquest in the name of the observation that Indo-European languages have spread worldwide. These dreaded leaders said the languages spread through military conquest in historical and prehistoric societies. Apparently, this should legitimize more conquest. Certainly, it is easy to find the remains of burnt cities and deduce that there was war, but does that mean that there was no Art? Good ideas, useful words, easily memorized songs, and well-recognizable cadences can make sense to many audiences, and they often spread by themselves. Perhaps the greatest gift of the Hymn to Nikkal is its musical echo of descending melodic lines and cadences found also in India, Greece, and later Rome. Were they simply something so good that people liked them—and over millennia? Perhaps, they connected people, and more so than the wars fought between them. With weapons, one can stop someone's heartbeat, with Art, one can make it go faster.

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