THE UNIVERSITY OF CHICAGO

Shared Poetic and Narrative Diction in Indo-European Epics: A Computational Analysis

By

Sruti Kanthan

August 2021

A paper submitted in partial fulfillment of the requirements for the Master of Arts degree in the Master of Arts in Computational Social Science

Faculty Advisor: Jon Clindaniel
Indo-European consultant: Emily West
Preceptor: Elizabeth Huppert

Shared Poetic and Narrative Diction in IE Epics: A Computational Analysis[1]

Abstract

In this paper, I investigate the possibility of a shared poetic and narrative diction distinct to epic within battle scenes in the two primary Indo-European epics: the Mahabharata and the Iliad. I use the Rig Veda and the Hesiodic corpus (the Theogony and the Shield of Heracles) as control texts, given that they derive from the same culture but belong to different genres. This investigation will attempt to (a) use quantitative methods to corroborate the longstanding hypothesis of literary and cultural Indo-European lineage, and (b) explore uncharted territory in mining structural similarities within large battle books that are difficult to hand-code. I used noun-adjective pairing frequencies and cosine similarity scores generated through SentenceBERT models to uncover poetic and narrative similarities in battle terminology shared between the texts. My overall findings suggest that patterns in poetic diction relating to battle terminology reveal both a stronger commonality of usage between the Indo-European texts as compared with the Near-Eastern influenced control corpus, and deeper commonalities between the two epics poetic diction concerning these battle terms than they share with other texts from within their separate cultures.

[1] I want to thank Professor Jon Clindaniel for his methodological guidance and encouragement. I would also like to thank Professor Emily West for her continuous support, and dedication in lending her historical expertise to this project. I must also thank Professor Hoyt Long for graciously giving me access to the BookNLP software that my analyses are based on.

Background

Indo-European migration

Since the 1900s, the evidence has been clear that an Indo-European (IE) linguistic and cultural wave swept out from the Pontic-Caspian steppes around 3000 BCE and became the dominant cultural and linguistic thread in every place it settled. Linguistic evidence also suggests that this dispersion spanned an area of roughly 500,000 - 750,000 square kilometers, although scholars are still debating what specifically constitutes the IE "homeland" (Anthony, 1995). Given the relative lack of physical markers left behind by this ancient civilization, scholars have combined linguistic and archaeological evidence to narrow down possible geographic boundaries through a process of elimination. Based on this data, a few example criteria for the homeland location include terrain conducive to farming, an area where the sky was one of the most striking features, and presence of honeybees (Anthony, 2010).

For more than 200 years, scholars who studied the IE migration believed it was a process of conquest by roving bands of warriors (e.g., Drews 1994, 1996, 2008, 2019), but the ancient DNA evidence so far does not support this, nor does it indicate that there was a specific IE gene pool (Grigoriev, 2021). Instead, archaeological and linguistic evidence suggests that the IEs were a mobile society that practiced herding, metalworking, were the first to domesticate horses, and assimilated more or less comfortably everywhere they went (Anthony, 2010). This explains why every IE language, ancient and modern, adopted enormous quantities of loanwords. The IEs were most likely not conquerors; rather, because they traveled slowly to allow their large herds of cows to graze, they were instead excellent assimilators who took pains to gain favor with the settled population they interacted with, including blending with their story traditions, sharing their languages, and ultimately adopting their ways. The Bronze Age was a violent time, and

there was certainly some violence involved, but no society which spread purely through violent conquest (such as the Huns, the Mongols, the Assyrians, or even the Romans) ever accomplished such a thorough and permanent expansion of language and culture.

Indo-European language and cultural dispersion

For at least the last four centuries, with Sir William Jones beginning a formal course of study in the 18th century, scholars have identified commonalities between Greek, Sanskrit, and a host of other languages, all of which point to the existence of a "parent" language that they have all ostensibly descended from. This theoretical, but linguistically attestable, language has been typed "Proto-Indo-European" (PIE), and it refers to the ancestor language that was spoken by the IEs and subsequently spawned a family of languages that extends across Europe and large parts of central and southern Asia, with over three billion speakers today. As captured by M.L. West (2007):

"If there was an IE language, it follows that there was a people who spoke it: not a people in the sense of a nation, for they may never have formed a political unity, and not a people in any racial sense, for they may have been as genetically mixed as any modern population defined by language … The IEs were a people in the sense of a linguistic community. We should probably think of them as a loose network of clans and tribes, inhabiting a coherent territory of limited size."

The subsequent movements and dispersal of these peoples left their mark on the languages of Europe and Asia. Commonalities between these descendant languages have been firmly established, and the existence of PIE has been agreed upon by the majority of the linguistics community (Watkins, 2001). Additionally, language convergence, or the possibility of

horizontal language exchange that might account for the "genetic" similarity, has been discounted as an explanation for the commonalities (Anthony, 1995).

Just as language dispersion is a natural byproduct of cross-continental migration, so too is cultural diffusion. IE mythology, religious, and ritual practices traveled along with the Indo-Europeans as they moved across the continents to new homelands. Thus, the mythological and ritual traditions of Greece, India, Iran, Rome, and Scandinavia are understood to be the volved genetic descendants of the IE steppe culture being carried along and passed down, through oral tradition and later written word, over many generations.

Qualitative research: IE parallels

The pantheon and religious traditions of IE cultures, Greece and India especially, have been studied extensively for the last hundred years. This is because the IE peoples that branched off to Greece and Iran (and later India), respectively, were the last to leave the IE homeland, making Greek and Sanskrit particularly fertile ground for finding IE poetic and narrative parallels.

Numerous parallel figures have been proposed, and several correspondences, backed by both linguistic and mythological relationships, are regarded as indisputable: the connections between Zeus and Indra, the adulterous, thunderbolt-wielding, ill-tempered kings of the Gods; Eos and Ushas, lustful goddesses of the Dawn; the bow and arrow wielding gods of love Kama and Eros, and Apollo and Rudra, hunters and archers with twin sisters, who serve as gods of medicine, are just a few (West, 2007). Anthony (2007) notes the cognate horse-goddesses Erinys/Saranyu, the guardian dog of the Underworld Kerberos/Sarvara, and the pastoral flock-guarding gods Pan/Pusan. Allen (2002) compares the gods Hephaestus and Agni, M.L. West (2007) connects Vedic Prajāpati with the Prōtogonos of the Greek Orphic tradition. Fowler

(1943) argues that the story of Prajāpati and his daughter is cognate with that of Erechthonius in Athenian myth. Grégoire et al. (1950), Grohmann (1862), and Arbman (1922) all connect Rudra and Artemis/Apollo. Chaturvedi (2016) makes connections between the Greek and Indic gods who govern cosmic order. The gods Shiva and Dionysus are presented as parallels in Bhattacharji (1988), as are the figures of Turnus and Duryodhana in Duckworth (1961). Further proposals may be found in; Lincoln (1986), Metzger (1946), Puhvel (1970), Sick (2004), West, M.L. (2007), Chaturvedi (2016), and Walker (2007).

The Greek and Sanskrit epics also share many sections of narrative and larger themes. Parallels include similarities in the night-raid motif - Garbutt (2006), Fries (2016); parallel "adventures of the wandering hero" - Allen (2014, 2019), West E.B. (2005, 2009, 2010, 2014), West M.L. (2007); cattle raids - Lincoln (1976), Sick (2004), M.L. West (2007); marriage contests conducted by archery, abductions of valuable female characters; and the all-consuming and apocalyptic wars at the center of both epic traditions (M.L. West, 2007).

Scholars have worked to analyze these similarities and understand which can be derived from a common inheritance rather than being a mere coincidence. A well-known adage in IE studies puts the evidence in three categories: "there are proposed "parallels" you are a fool *to* believe; there are proposed parallels you are a fool *not* to believe, and those that have to be borne in mind as possibilities until the evidence can give us a clearer answer." Many shared features of these texts are too similar - shared root words occurring at the same point in the narrative, for instance - to have been the product of chance.

Indo-European literature

The speakers of PIE did not have written language and primarily passed down stories through oral tradition, setting poetic meters and repetitive phrases to facilitate recall. Their

narratives were captured in writing by their descendants as epics and hymns that typically fossilized their poetic form. Epics are long, narrative poems that often narrate stories episodically, and describe the values and experiences of the culture through the hero's perspective. While both hymns and epics feature myths, hymns feature a more religious overtone. In the present study, I focus on four texts: the Mahabharata and Iliad (epics), Hesiodic texts (poems), and Rig Veda (hymns).

Text overview – *listed in order of proximity to PIE*

The *Rigveda* is the most ancient Hindu religious text known (dated anywhere between 1100 BCE and 1500 BCE) and is closest in time to PIE. It contains hymns of praise for ancient Hindu gods, moral and societal dictates, and explores cosmological and philosophical questions.

The *Iliad* is an ancient Greek epic that was written down around 800 BCE, but also contains material from at least 2000 BCE, making it both Greek and IE descended. It spans 15,000 lines and describes the events leading up to the Trojan war, and the war itself. There was unlikely to have been a single author, but the text is conventionally attributed to Homer.

The *Mahabharata* is an ancient Indian epic that was codified in writing around 500 BCE, but contains cultural material that likely dates to at least 1700 BCE. The text comprises over 100,000 lines and describes the events leading up to the battle of Kurukshetra and the battle itself. While the epic is clearly a vast compilation which aggregated over time, it is attributed to a mythological single author known as Vyasa. Given its culmination over centuries, the Mahabharata features elements of IE *and* Indic influences, the latter being characterized by flowery, adjective-laden language). Both the Iliad and Mahabharata share themes of duty and honor and describe the implications of an apocalyptic war.

The *Theogony*, a thousand-line poem about the conception of the universe written by Greek poet Hesiod around 700 BCE, was produced in essentially the same cultural context and dialect as the Homeric epics. The *Shield of Heracles* was also written by Hesiod, but it is 480 lines long and details Hercules' fight against Cycnus. I decided to include this text as a supplement to *Theogony*, given that it pertains more to battle and was written by the same author, which would reduce noise stemming from multiple translations or styles of writing. For the purposes of this paper, *Shield of Heracles* and *Theogony* function as a single combined control text, dubbed "Hesiodic text" in the analysis. This combined text's literary style and character are much closer to that of ancient Near Eastern literature, making it *partly* Greek influenced, not directly IE descended, and therefore distinct in character from the other three texts in the analysis.

These texts were chosen because they are the largest repository of data available, provide an even mixture of religious and battle descriptions, and are temporally balanced as well: the Iliad and Rig Veda are closer in time to PIE, while the Mahabharata is further away in time from it, and the Hesiodic text arose in a Greek milieu and features substantial Near Eastern influences, giving it theoretical justification as a control text. One of the questions of interest in this paper is whether genre, culture, or proximity in time to PIE has the greatest bearing on poetic and narrative similarity between texts. More specifically: whether any poetic or narrative qualities that the Iliad and the Rig Veda might share could be attributed to their being closer in time to PIE, or whether any qualities the epics may share stem more from being of the same genre and coming from the same tradition of narratives transmitted through oral-poetic composition.

Of note, the selected texts share some overlap in genre or proximity to PIE. There is slight overlap in deities but no known narrative overlap between the Rig Veda and the Iliad; the

Iliad and Mahabharata are Indo-European epics and therefore the same genre; the Iliad, Mahabharata, and Rig Veda are classified as Indo-European poetry, but the Rig Veda is a compilation of hymns and is therefore not the same genre; Iliad and Hesiod are both relics of Greek culture and are written in the same language, but are different genres given Hesiod's Near-Eastern influences; Hesiod and Rig Veda are hymns to the gods, and are therefore the same genre but from different cultures; and finally, the Rig Veda are both Indic and Indo-European, but are of different genres. The Mahabharata and Hesiod do not overlap on any of these fronts.

Qualitative research in Indian and Greek epic similarity

The epic narrative traditions of Greek and India are the largest repositories of evidence about IE oral narrative, and most conducive to finding parallels -- but the most poorly explored relative to their size. While extensive comparative work has been carried out by IE linguists over the last few centuries, it is only in the last several decades that scholars have begun to analyze parallel scenes and figures in every other part of Homer and the Mahabharata. For instance, Allen (2002, 2007, 2010, 2014, 2016, 2019) demonstrates underlying shared patterns in hero myths present in the Greek and Sanskrit epics. Other explorations in this area include identifying similarities between pairs of titular characters in these epics: Draupadi and Helen, abducted women who were born to destroy warriors (Aggarwal, 2019; Jamison, 1994); Kings (Drupada - Agamemnon) who brutally rebuff a priest and retaliate with the help of a skilled archer (Arjuna - Apollo) (Allen, 2016); physical vulnerability in an unexpected area that leads to the warrior's downfall (Achilles - Karna); and supernatural spectators who take sides as the war unfolds (Allen, 2002). Vassilkov (1971) and (1973) found that the major "themes" (the narrative frameworks used by oral poets to compose their tales) in the Mahabharata include duels, ascetic

exploits, requests made to storytellers, receptions of guests, and descriptions of nature - with the exception of “ascetic exploits”. All the above are the most common themes in Homer as well.

One area of the epics, however, has remained especially unexplored by comparativists: the battle books of the Iliad and Mahabharata. These accounts of the fighting in pyrrhic wars form the centerpiece of both traditions. Aside from the “Night Raid” (Garbutt, 2006; Fries, 2016) and a battle scene in which a goddess briefly drives a chariot to rescue an unconscious warrior (West, 2006), there have been no treatments or comparative work carried out in the war-based sections of the texts. One reason for this is that they are very dense—and, in the case of the Mahabharata, enormous. However, this very quality makes battle scenes in the epic especially conducive to computational analysis. Brockington (2009) notes that in the Mahabharata, battle scenes contained the most formulae (didactic sections contained the fewest), and that given the importance of the formula in Homer, the presence of formulaic phrasing probably indicates a greater density of inherited Indo-European material. Moreover, Classicists who work on Homer have found that many scenes of individual combat between warriors in the Iliad follow a formulaic pattern of sequential actions (typescenes), likely to make memorization in the oral tradition easier (Fenik, 1968). This structure lends itself well to analysis by computational clustering algorithms, which are adept at identifying patterns in data - potentially ones that human coders missed.

It is useful to identify commonalities between IE-descended epic traditions because it is valuable for people who study the Homeric epics to understand what came before those epics, just as it is for people who study the Mahabharata (and the same for what remains of Norse myths, and Iranian religion and myth). For people interested in reconstructing IE culture, given the abundance of linguistic evidence and comparative lack of archaeological evidence, this is the

only path that they have. It is also useful for people who study the cultures that were already in place before the Indo-Europeans arrived, such as the Minoans, the Dravidians, and all the cultures of Asia Minor. Without mapping out what parts of the narratives are likely to be persistent from before the Indo-European arrival, it is very hard to trace out the possible contributions of the prior societies in those places – or contributions of societies from after the Indo-European arrival.

Computational perspective: existing work

While qualitative evaluations of shared IE features are abundant, a literature review of studies that perform computational analyses, especially for battle scenes, turned up scant results. Das, Das, & Mahesh (2016) synthesized NLP, sentiment analysis, and social network analysis methods to uncover patterns in the Mahabharata, and validated the findings established by literary scholars while pointing out subtleties that might have been difficult to observe through human coding alone (e.g., Kunti's understated influence in through her centrality scores and ego network size). Other scholars like Tehrani and d'Huy (2017) used cladistic reconstruction to try and trace a collection of myths to a common ancestor, and later attempted to reconstruct the Proto myth that they descended from. Aggarwal (2019) presented a qualitative comparison of thematic similarities in the Mahabharata and Iliad, which builds on an existing repository of qualitative analysis on the text that has paved the way for more quantitative approaches. Very little work has been done on computational cross-comparison of the Mahabharata and Iliad, and I have not come across any studies studying them in the context of shared battle customs.

Noun-Adjective Pairings

The bulk of this study examines the usage of adjectives employed as direct modifiers of nouns of interest (i.e., not as predicate nominatives[2]). This method is in accord with the long-standing practice of identifying such pairs as evidence of traces of IE speech patterns still preserved in the text, and harkens back to seminal work on IE linguistics such as Adalbert Kuhns' (1853b:467) recognition that Homeric Greek *kleos aphthiton* (Il. 9.413) and Rigvedic *sravas aksitam* (1.9.7bc) were both expressions of the same IE phrase, "undying fame." Many other studies on IE poetic diction followed, including Schmitt (1967, 1968), Smith (1999), and Watkins (2001). While the formulae in the Mahabharata are not as flexible or metrically simple as those in Homer, formulae fixed by tradition figure into the composition of the Mahabharata (Brockington, 2009), and the presence of so many formulae in Homer was the first indicator used by scholars to discover the text's oral origins.

The methodology utilized here was chosen for several reasons. One was that it would allow for a high level of confidence in the likelihood that the translation accurately preserved the syntactical and semantic relationship between nouns and adjectives and would shed light on patterns inherited from an IE precursor.[3] Patterns regarding the application of adjectives to nouns are a significant part of poetic diction, and speech in general. Unlike nouns and verbs, adjective modifiers for nouns are completely optional in a sentence; they have no other role than to add color and imagery to a narrative. When considered in terms of familiar narratives, the

[2] The only adjectives considered in this study were those used to modify nouns directly. Thus, an instance such as "He drove the **swift chariot** towards his comrades" would be considered, but not "He drove a **chariot** which was **swift**" or "I see that your **chariot** is **swift**." The distinction narrows the frame of examination to words which are most closely linked in the mind of the poet.

[3] Several classicists and Sanskritists were consulted on the feasibility of this premise, including S. Douglas Olson from the University of Minnesota for Greek, and both Jesse Knutson at the University of Hawaii and William Malandra, emeritus at the University of Minnesota, for Sanskrit. All agreed that translators were highly unlikely to disrupt these sentence structures---all of which are easily and naturally preserved in English---in the course of translation. Additionally, Emily West examined a random selection of instances collected in the study, and none of them incorrectly assigned predicate adjectives as noun modifiers.

difference in impact between a story about “the wolf” versus a story about “the big bad wolf” is clear. Particularly when discussing orally composed and transmitted narratives, adjective modifiers combine with nouns to become metrically useful blocks of narrative which are indispensable to an oral poet’s craft. Additionally: in oral tradition, words that tended to co-occur continued to persist in this form—a phenomenon that was particularly true for the epics (e.g., “swift-footed Achilles”). It stands to reason that if the IE bards that started this tradition had a particular way of referring to events in the epics, that style may have persisted as they branched off to different places. Limited stylistics with Indo-European bards make these similarities even more meaningful (Bassett, 1922).

Given their volume, density, and utility as a fossil of a culture’s experiences, epics lend themselves well to computational analysis, especially at the word-level. In the present study, I will be studying similarity between the adjectives used to modify the primary pieces of battle equipment used in the epics: “arrow(s)”, “spear(s)” and “chariot(s)” in the Sanskrit epic *Mahabharata*, and the Greek epic *Iliad*. Given the proven history of shared commonalities between these linguistically related cultures, this study seeks to uncover whether IE epics habitually associated these items with specific ideas or qualities, and whether those associations were retained as the epics evolved into their eventual final forms.

To better isolate patterns in battle that are particular to the epics, I will use computational approaches to compare the Mahabharata and the Iliad to each other, and then compare these texts to the Rig Veda and Hesiodic texts respectively. Thus:

RQ: Can we find evidence of an IE poetic diction related to battle (in other words: the way the IEs regularly employed specific descriptors to certain nouns, such as “Undying Fame”? Are there recoverable, formulaic expressions (IE formulae) for battle-related items (spear, arrow,

chariot) preserved in the epic literature, or do the two epics at least resemble one another's usage patterns more closely than they do works of a different genre from the same cultural context? Furthermore, can we isolate any greater, or more specific, similarities between the two epics (the Mahabharata and Iliad) than are shared between all four texts? Can we recover any evidence for formulas relating to military equipment and activities?

This research question is further distilled into five hypotheses:

H1: The Mahabharata and the Iliad (being in the same genre) will modify these war-related terms with adjectives at similar rates, i.e., both texts will likely call a chariot a "swift chariot" (versus simply "a chariot") or an arrow "a deadly arrow" (versus simply "an arrow") a similar percentage of the times these terms are mentioned.

H2: The two epics will apply similar classes and types of adjectives to the search terms, suggesting that even though they evolved in separate cultural contexts for some 500 to a thousand years, they retain traces of a shared poetic diction inherited from Indo-European Proto-epic.

H3: I am expecting a shared trend in frequency of mentions of chariots in the epics (relative to their size), given that chariots were central to the Indo-Europeans, they took pride in their vehicles' craftsmanship and utility, and in both epics chariots remained centrally important in warfare (although warriors fight from their chariots in the Mahabharata a larger percentage of the time than they do in the Iliad, where a hero is more likely to drive to the battlefield and then disembark).

H5: Both epics will contain noun adjective pairs which are repeated many times. Formulaic diction is the Homeric characteristic which led to the recognition that it was orally

composed and transmitted (Lord, 1973) and an important part of the Mahabharata's verbal style as well (Brockington, 1998).

Measures and method

Data:

After consulting with Emily West[3] about reliable online Greek and Sanskrit translated text sources, I scraped the full text of the Mahabharata and Rig Veda from sacred-texts.com. I scraped the text from the Iliad and Theogony from perseus.tufts.edu, and scraped the text for Shield of Heracles from theoi.com. I subsequently used standard text cleaning methods to remove all punctuation, Unicode characters, and stop-words in the texts. All scraping was completed with the `requests` and `beautifulsoup` libraries, and all text cleaning was completed with the `nltk` and `spacy` libraries. I used Python for both processes.

Methods:

1. Adjective similarity analysis

This method constitutes the central approach of this paper. First, a series of war-related nouns were selected: "arrow(s)" (also searched for under their frequent synonym "shaft(s)"), "chariot(s)" (also searched for under their frequent synonym "car(s)"), and "spear(s)". These words were chosen because they were frequently used in battle in all four texts, were robust to translation error, and were likely to have been translated into English in the same way. Anthony (2007) notes that there is shared Indo-European vocabulary in Greek and Sanskrit for "bow", "arrow", "bowstring" and "club", but both languages contain loanwords for these items as well, so the searches would not automatically imply that items would share an Indo-European root word. Next, I used the `kwic`() function from R's `quanteda` library to document each keyword's occurrence in the four texts, as well as the word that immediately preceded each keyword

(dubbed “descriptor”). These instances were documented as csv files of noun-descriptor pairings (e.g., *winged arrow*; *the spear*). Then, after testing its classification accuracy rate on my data, I used BookNLP’s Stanford part-of-speech tagger to assign each descriptor a part-of-speech tag, recorded the proportion of adjective descriptors relative to other parts of speech, and stored a list of the adjectives with respect to the noun they were paired with. After a named-entity-recognition approach failed to properly classify the adjectives into groups, Dr. West organized these adjectives into discrete categories and performed counts within each tier. She subsequently searched for salient adjectives (i.e., those that pointed to a unique shared pattern between the epics by referencing materials that were used by IEs, bore religious significance in both cultures, etc.) in the original Greek and Sanskrit texts, to check for shared IE cognates. Searching for adjective trends by *category* allowed us to better organize the analysis and identify more granular differences in how IE-descended cultures describe key elements in warfare.

Analysis of the relationship between the Greek and Indic branches of IE epic proceeds on two fronts: the first task that IE mythologists faced was making a case that the structural and thematic similarities between the two epic traditions constituted proof of a true genetic relationship. The second task, therefore, is explaining and accounting for the obvious differences between the two traditions introduced during the period of their separate evolution in their new homes from 2,000 BCE onward. Analysis of the poetic diction relating to spears, arrows and chariots appears to have something to offer to both ongoing projects.

2. Pairwise sentence embeddings

The noun-adjective analysis explores similarities on a granular, poetic level, but exploration of broader narrative similarities could be fruitful as well. I therefore supplemented the adjective analysis with pairwise sentence embedding analysis using SentenceBERT, a

revolutionary model that considers each word in a sentence and uses this information to calculate the embedding (i.e., numerical, computer-friendly representation) of an entire sentence. Therefore, it is contextualized, unlike other word embedding models like word2vec—meaning that it is particularly adept at differentiating homonyms. This method allowed me to find pairs of highly similar sentences across the four texts, with similarity being operationalized through cosine similarity. Proximity to 1 signals higher similarity in a given sentence pair, and scores closer to 0 suggest a lower level of similarity.

To isolate sentences from each text that were germane to my research questions, I created three separate lists of keywords related to the sun, feet, and battle, and filtered out sentences that did not contain any of these keywords. My rationale for these categories was that the sun god was a key actor in both epics, and sun often acts as a marker of time during ancient battle scenes, making it a particularly meaningful symbol. I included foot-related keywords because of the foot's connection with fate in religious texts (e.g., Achilles' death by arrow to the heel and Krishna's death by arrow to the sole; Nikolopoulou, 2007). Given a lack of availability of built-in anatomy dictionaries in R or Python, the keyword lists were hand-written and validated by Dr. West[3].

For each non-repeating combination of the four texts, I compiled all the sentences that contained any of the keywords listed in Table 1. I subsequently compared each sentence in a given text against all other sentences in the three remaining texts, until all pairs of sentences across all four text combinations had been evaluated for similarity against each other (6 text combinations x 3 keyword types = 18 total analyses). To restrict the primary dataset as closely as possible to epic battle scenes, I limited my data to the battle books for the Mahabharata (5-10), the battle books for the Iliad (3, 5-8, 10-17, 20-21), and kept all the text from the Rig Veda and

Hesiodic corpus (all of which contain scenes and references to battle, but with religious, rather than epic narrative, contexts).

Table 1: Keywords for SentenceBERT analysis

Keywords		**Text Combinations**
Sun	[dawn, rising sun, sunrise, sunset, sun set, dusk]	Mahabharata x Iliad Mahabharata x Rig Veda Mahabharata x Hesiod Iliad x Rig Veda Iliad x Hesiod Rig Veda x Hesiod
Foot	[foot, sole, feet, heel, ankle]	
Battle/injury	[arm, forehead, trunk, sever, cut, blood, spurt, gush, slash, shaft, car, arrow, spear, chakra, sanguine, leg, thigh, groin, shoulder, stomach, pierce, stab, chest, breast, torso, bleed, kill, die, perish, throat, moksha, bled]	

Given that almost all text pairs (with the exception of Mahabharata and Hesiod) overlap on one of the three aforementioned levels, I expected that SentenceBERT may identify text similarity based on any of these possibilities, but hypothesized that it would parse out epic-related narrative similarities by assigning IE-descended narrative particularly high cosine similarity values. I anticipated that the Mahabharata and Rig Veda and Iliad and Hesiod text pairs would also feature very high cosine similarity scores, given that the content of discussion would likely share overlap on a cultural level (references to specific Gods, etc.) that SentenceBERT would pick up on, even though they are of different temporal "distances" from original PIE phrasings and are of different genres. In the same vein, I expected the Mahabharata

and Hesiod text pairs to have the lowest scores. On the whole, despite expecting SentenceBERT to favor sentence pairs that featured cultural similarity, I also anticipated that it would identify clear IE-derived narrative similarities between the epics that would stand in contrast to sentences from Hesiod (i.e., far lower similarity scores), keeping with the five hypotheses outlined..

Results

Noun-adjective analysis

Spears

While the spear is an ancient weapon known and used in all IE societies, its use in the texts under consideration is far from uniform. While spears are mentioned in all four texts, the Iliad mentions spears nearly 18 times as often despite being one-eighth the size of the Mahabharata, and spears are found even less frequently in the Rig Veda. Where Indic texts modified "spear(s)" with adjectives less than a quarter of the time, the Iliad assigned an adjective to it in roughly one third of occurrences; and in Hesiod, though there were proportionately fewer occurrences, a full 50% were modified:

Table 2: Percentage of adjective modification for "Spear(s)"

Iliad	**Mahabharata**	**Rig Veda**	**Hesiod**
31% [524 total] 165 w/ adj.	23% [30 total] 7 w/ adj.	19% [21 total] 4 w/ adj.	50% [14 total] 7 w/ adj.

This strongly suggests that spears were not a favored weapon in the IE context, and that it was only as a part of Bronze Age/Dark Age Greek warfare that they became a weapon of interest in the Greek world (e.g., Bassett, 1922). This focus was not shared in Hesiod, which contains far fewer references to spears (14 total uses, compared to the Iliad's 524; therefore, while the Iliad is roughly 10 times as large as the combined Theogony and Shield of Heracles, it mentions spears

14 times as often). This may be attributed to Near-Eastern influence pervading over the Greek context.

Across the four texts, adjectives modifying "spear" fell into nine general categories, but only one category of adjective is applied in all four: unsurprisingly perhaps, this most-widely-noted quality is "length", with at least one usage in each text. However, the use of the descriptor was also surprisingly uniform across the surveyed texts, accounting for roughly 25% of adjectives applied to "spear(s)" in the Indic and Hesiodic, while descriptors relating to length account for 30% of the adjectives modifying spears in Homer (Table 2a[4]).

The next most obvious quality of a spear, sharpness, was noted in both epics and Hesiod, but with a slightly greater disparity in volume (Table 2b). The quality of "brightness" or "shininess" was also relatively broadly occurring, with examples in all three primarily IE-derived texts. While the frequency in the Iliad was 12%, it was more than double that in the Mahabharata, and "shininess" accounted for 50% of the Rig Vedic adjectives applied to "Spear(s)" (Table 2c).

Of particular note: two categories -- references to quantity and shape -- occurred *exclusively* within the two epics. The Indic text only contained exactly one instance within each category. In contrast, the Iliad used each category with very different frequencies. It contained only one reference to spears in quantity, and a small number of references to their shape (Table 2d).

The Iliad and the Hesiodic texts shared occurrences of three characteristics. One, "dangerousness", received two mentions in Homer, and one in Hesiod. A more telling

[4] Information about the specific adjectives and their respective counts can be found in Tables 2a-f (spears), 4a-f (arrows), and 6a-d (chariots) in the appendix. Tables 2-7 provide general information about the adjectives counts by category.

commonality is the references to the metal of which the spears are constructed: bronze. While 8% of the Iliad's references are to the ash-wood spears were generally made of, 5% note the use of bronze for the point and the shoe. In Hesiod, 28% of the modified references to spears (2) refer to their bronze construction; neither the Mahabharata nor the Rig Veda referenced this quality. Lastly, modifiers referencing a spear's strength occurred 9% of the time in the Iliad, and 14% of the time in Hesiod (Table 2e).

Finally, 7% of the adjectives modifying spears in the Iliad, mostly attributions of quality, have no clear-cut counterparts in the other texts (Table 2f). Below is a summary of all adjective occurrences for "spear(s)" across each text, which offers an overview of category overlap across the texts:

Table 3: Adjective occurrence summary for "Spear(s)"

Category	**Frequency and percentage of adjective total**			
	Iliad	**Mahabharata**	**Rig Veda**	**Hesiod**
length	50 (31%)	2 (29%)	1 (25%)	2 (29%)
sharpness	32 (20%)	1 (14%)	0	1 (14%)
brightness	20 (12%)	2 (29%)	3 (75%)	0
quantity	1 (.6%)	1 (14%)	0	0
shape	6 (3%)	1 (14%)	0	0
Dangerousness	2 (1%)	0	0	1 (14%)
material	23 (14%)	0	0	2 (29%)
strength	16 (10%)	0	0	1 (14%)
general good qualities	13 (8%)	0	0	0

Arrows

Just as "spear(s)" become the primary weapon of war within the text of the Iliad, "arrow(s)" are the signal weapons of the Mahabharata, and that text (accounting for the fact that the text is 11 times as long) refers to "arrow(s)" slightly more than twice as frequently as the Iliad does. In terms of general poetic diction, the Iliad and the Mahabharata apply descriptors to "arrow(s)" at similar overall rates: 31% of the occurrences of the word "arrow(s)" are accompanied by adjectives in the Iliad, and 35% in the Mahabharata. This similar rate of application in the epics is consistent with the theory that descriptions of combat in IE epic inherited a shared pattern of description which persisted even as the original narrative and cultural contexts evolved separately, supporting my first hypothesis. In the case of "arrow(s)", the two epics bear far more overall similarity to one another than they do to their control texts. Given the significance of the bow as a marker of heroic distinction in both texts (the heroes Arjuna and Odysseus are particularly renowned as bowmen, and bridal contests in both epics are centered around archery competition), it is not surprising that an IE poetic diction surrounding arrows might persist in a Greek context, even as the culture moved towards different forms of warfare.

The Rig Veda was more sparing at pairing adjectives with "arrow(s)", applying them only 24% of the time, and the Hesiodic text did so 25% of the time. The similar rates in Hesiod and the Rig Veda may be due to coincidence, or to a similarity inherent in the material treated in more religiously-inclined texts, or it may be that the Rig Veda represents a baseline pattern of diction for IE texts which, in spite of its obvious Near Eastern influences, Hesiod absorbed as well. Certainly, a combination of all of these factors is also possible.

Table 4: Percentage of adjective modification for "Arrow(s)"

Iliad	**Mbh.**	**Rig Veda**	**Hesiod**
31%	35%	24%	25**%**
[114 total]	[3184 total]	[82 total]	[8 total]
36 w/adj.	1,020 w/ adj.	20 w/ adj.	2 w/ adj.

The adjectives paired with "arrow(s)" largely fell into thirteen fairly clearly-defined categories, with the exception of a group of miscellaneous descriptors which occurred only in the Mahabharata, and accounted for about 7% of the adjectives that text applied to "arrow(s)" (Table 4a).

With 3,184 total references to "arrow(s)" (as compared to the Iliad's 114 -- 27 times more in a text only eight times as large), it is clear that the Indian epic invests a great deal of interest in the arrow as a weapon; the Iliad places emphasis on the spear in much the same way. However, in spite of differing emphases on these weapons' centrality in warfare, the epic poets seemed to have continued to use similar patterns of poetic diction.

Just as the similar percentages of descriptors used on words for "arrow" in the two epics suggests this shared poetic diction, further evidence also suggests that the concept "arrow" was characterized in the two epics in similar ways. Four categories (description of arrowhead, materials, quantity, and wingedness) were shared only by the two epics, accounting for 34% of adjective use with "arrow(s)" in the Iliad and 29% of adjective use with "arrow(s)" in the Mahabharata. The most striking commonalities occurred in the use of adjectives explicitly describing the shape or material composition of the arrows head. The Iliad used such descriptors 17% of the times the word arrow was modified, and the Mahabharata 14%, another remarkably similar rate. Both epics also contain a handful of references to the materials of which arrows are

constructed. The Greek texts both referred several times to the ash and bronze of which spears were constructed, but another surprising commonality comes in the form of references to "golden" arrows. Additionally, while the Mahabharata frequently describes arrows as coming in enormous volleys (in keeping with its tendency to fantastical battle descriptions), the Rig Veda and Hesiod never allude to large quantities of arrows, but the Iliad does contain one reference to "many" arrows. Finally, the most interesting common feature is a shared pattern of identifying arrows as "winged," at rates of 8% (Iliad) and 2% (Mahabharata). The words employed to do so (πτερόεις in the Greek and *patatrin* in Sanskrit) both derive from the IE root *pat* "to fly," "to fall," but as adjectives, both refer specifically to the presence of wings, not the ability to fly (i.e., "winged", not "flying"). Describing an arrow as "flying" would be completely natural, but referring to their fletching as "wings" is a metaphorical extension which could easily indicate shared inheritance (Table 4b).

After the descriptor categories shared only by the two epics, there are another four shared by all the primarily IE texts but are absent from the Hesiodic corpus. Three of these (speed, sharpness, and fletching), are entirely predictable as modifiers for arrows. Of interest regarding the speed, sharpness, and fletching categories is that the Iliad and the Rig Veda (the IE texts least separated by time) have quite comparable vocabulary patterns for the use of these terms, and it is only the Mahabharata's explosive tendency towards adjective use that differentiates it. Otherwise, the only major outlier is that swiftness is clearly not a highly-valued characteristic for arrows in the Indian epic. The overall rarity of general references to fletching is also surprising (Table 4c). A final, though extremely rare, commonality between the three IE texts is the attribution of virtuous qualities to arrows (Table 4d).

Three categories of descriptor were exclusively present in the two Indic texts: the arrows quality/strength, the arrows attractiveness, and how well it was aimed (Table 4e). The only category of adjective which could be found in all four texts was also the only one to be found in the Hesiodic corpus: "attributed ill-intent or cruelty" (Table 4f). Table 5 (below) summarizes the "arrow(s)" adjective categorization and text overlap:

Table 5: Adjective occurrence summary for "Arrow(s)"

Category	**Frequency and percentage of adjective total**			
	Iliad	**Mahabharata**	**Rig Veda**	**Hesiod**
Description of arrowhead	6 (17%)	136 (13%)	0	0
Materials	2 (5%)	12 (1%)	0	0
Quantity	1 (3%)	109 (10.5%)	0	0
Winged	3 (9%)	30 (3%)	0	0
Speed	6 (17%)	12 (1%)	2 (10%)	0
Sharpness	3 (8 %)	349 (34%)	5 (25%)	0
Fletching	4 (11%)	32 (3%)	1 (5%)	0
"Virtuous" qualities	1 (3%)	< (.001%)	3 (15%)	0
Might & performance	0	172 (17%)	3 10%	0
Attractiveness	0	31 (3%)	2 (10%)	0
Aim	0	3 (.5%)	2 (10%)	0
Ill-intent or cruelty	13 (36%)	91 (9%)	3 (15%)	2 (100%)
Miscellaneous	0	72 (7%)	0	0

Chariots

Table 6: Percentage of adjective modification for "Chariot(s)"

Iliad	**Mahabharata**	**Rig**	**Hesiod**
[256 total]	[1691 total]	[698 total]	[17 total]
27 w/adj.	156 w/ adj.	144 w/adj.	9 w/adj.
10%	9%	22%	53%

The range of descriptors applied to chariots was condensed into nine categories,[5] each of which had a distinct distribution pattern within the texts. Adjectives relating to chariots shared by all the texts fell naturally into three categories of highly practical and essential descriptors: "Quality of Construction", "Speed", and "Shape & form", but did so at vastly different rates: 44% of the Iliad's adjectives for "chariot(s)", 25% of the Rig Veda's, and 78% of those in Hesiod come from these categories, yet only 4% of the Mahabharata's are of these types. Interestingly, an additional 4% of the Mahabharata's "chariot" adjectives and a surprising 8% of the Rig Veda's fell into no particular category and found no analogues in other texts (Table 6d).

An obvious descriptor of a chariot is its wheel function.[6] The Rig Veda employs adjectives relating to wheel function 14% of the times it describes chariots, and the exclusively practical Hesiodic corpus 22%, where the Iliad uses "well-wheeled" once, and the Mahabharata never refers to a chariot according to its wheel function (Table 6b). However, when the terms for wheel function utilized were checked by a linguist[3], while the terms did indeed have similar meanings, they did not come from shared IE root words. When it comes to "Functioning," therefore, the Iliad (and ironically Hesiod) is closer to the Rig Veda than to the Mahabharata, even if the two texts are not using IE words for the shared qualities.

[5] I.E., the focus is on meaning and associations rather than specific word choice.

[6] In fact, the concept of a chariots wheel function is so important in early Indic texts that the concepts of *sukha* and *dukkha*, "happiness" and "misery" are actually compounds meaning "having a good axle-hole" and "having a bad axle-hole," the idea being that living a serene life is like riding in a well-constructed and smooth-running chariot.

On the opposite end of the spectrum, adjectives relating to a chariot's beauty were completely absent from Hesiod, but comprised 52% of the Iliad's, once again indicating an area in which the Iliad's poetic diction far more closely resembles the other IE texts than it does that of its near-contemporary in the same language. It's also worth noting that the two epics described chariots as "beautiful" at rates more similar to one another than those of the Mahabharata to the Rig Veda (Table 6c).

Supporting the idea that the Mahabharata prefers to engage with chariots when they represent status items --rather than workmanly ones-- the three categories which are shared by the two Indic texts (35% of the Mahabharata's adjectives) are those describing chariots as "golden," describing their strength and might, or the way they showcase wealth (Table 6d).

On the whole, in spite of being perhaps the most widely regarded symbol of Indo-European battle styles and engineering achievements, discourse around chariots in the three Indo-European texts was less uniform than could be expected, but there were still plenty of commonalities. Below is a table that summarizes the category overlap in chariot adjectives across all four texts:

Table 7: Adjective occurrence summary for "Chariot(s)"

Category	**Frequency and percentage of adjective total**			
	Iliad	**Mahabharata**	**Rig**	**Hesiod**
Quality of Construction	3 (11.5%)	2 (1%)	3 (2%)	2 (22%)
Speed	2 (7%)	4 (2.5%)	10 (7.5%)	2 (22%)
Shape & form	7 (26%)	1 (.5%)	23 (16%)	2 (22%)
Beauty	14 (52%)	88 (57%)	40 (28%)	0
Rolling & wheels	1 (3.5%)	0	21 (14 %)	3 (34%)
Golden	0	18 (11.5%)	14 (10 %)	0
Strength and might	0	33 (21%)	15 (10.5%)	0
Exhibition of wealth	0	4 (2.5%)	6 (4%)	0

Miscellaneous	0	6 (4%)	12 (8%)	0

Epic overlap and support for IE parallel

The Mahabharata and the Iliad were the only texts that used "winged" as a descriptor for arrows, an adjective that derives from the same IE root. They also did not focus on the attractiveness of the weapon they each preferred (arrows vs. spears), but focused on *chariots'* beauty a great deal, despite only describing chariots with adjectives 9-10% of the time. Given that this mismatch in focus is also found in the Rig Veda, the text closest in proximity to PIE, and *not* in Hesiod, special emphasis on a chariot's beauty may be a poetic vestige unique to IE-descended work.

Table 8: Summary of adjective categories shared by Epics

Word	**# Categories shared**	**% Categories shared**	**Percent in Iliad shared w/ Mahabharata**	**Percent in Mahabharata shared w/ Iliad**
"Arrow(s)"	9/13	69	100%	79%
"Chariot(s)"	4/9	44	100%	61%
"Spear(s)"	5/9	55	67%	100%
Total	19/30	**Average: 56%**	**Average: 89%**	**Average: 80%**

The high number of shared categories in the Iliad and Mahabharata, coupled with the similar high scores in the percent shared on both sides, as well as their overall similar rates of adjective application to the keywords studied,[7] also argues strongly for a persistent form of

[7] For example, the Iliad applied adjectives to 31% of its uses of the word "Spear(s)" and the Mahabharata 32%; for "Arrow(s)", the Iliad applied adjectives to 31% and Mahabharata to 35%; and for "Chariot(s)", the Iliad and Mahabharata attributed 10% and 9% respectively.

discourse for battle paraphernalia; one which traveled with the epics as they evolved within their new, separate cultures. This finding supports my first and fifth hypotheses, regarding similar noun modification rates and noun-adjective pairing repetitions between the epics.

The Mahabharata and Rig Veda have roughly the same percentage of overall similarity, but it is less balanced and thoroughgoing; the similarities are lopsided, with the Rig Veda's adjective categories acting as a subset of the Mahabharata's - but not vice versa.

Table 9: Summary of adjective categories shared by Mahabharata and Rig Veda

Word	**# Categories shared**	**% Categories shared**	**Percent in Mahabharata shared w/ Rig Veda**	**Percent in Rig Veda shared w/Mahabharata**
"Arrow(s)"	8/12	66	58%	100%
"Chariot(s)"	8/9	88	100%	86%
"Spear(s)"	2/9	22	58%	100%
Total	18/30	**Average: 63.3%**	**Average: 72%**	**Average: 95%**

The Mahabharata actually shares more of its adjectives relating to battle paraphernalia with the Iliad (80%) than it does with the Rig Veda (72%). That is very surprising, given that the Rig Veda is the ultimate cultural authority in the Indic context, and it is referred to and deliberately emulated repeatedly in the text. In spite of this, the evidence seems to suggest that with the exception of fewer shared adjective categories for chariots, the underlying epic tradition had more influence over how the Mahabharata discussed weaponry than the Rig Veda.

There is less overall similarity between the Iliad and the Rig Veda, the texts closest in terms of temporal proximity, but still more than there is between the Iliad and Hesiod, as observed below:

Table 10: Summary of adjective categories shared by Iliad and Rig Veda

Word	# Categories shared	% Categories shared	Percent in Iliad shared w/ Rig Veda	Percent in Rig Veda shared w/ Iliad
"Arrow(s)"	5/12	41	75%	61%
"Chariot(s)"	5/9	55	100%	67.5%
"Spear(s)"	2/9	22	43%	100%
Total	12/30	**Average: 40%**	**Average: 73%**	**Average: 76%**

The Iliad and Hesiod have some commonalities, but not nearly as many as one might expect from two texts that are from same time period and share cultural overlap. Note the massive difference in the blue numbers in Table 11; Hesiod's discourse is a restricted subset of what is found in the Iliad:

Table 11: Summary of adjective categories shared by Iliad and Hesiod

Word	# Categories shared	% Categories shared	Percent in Iliad shared w/ Hesiod	Percent in Hesiod shared w/Iliad
"Arrow(s)"	1/12	8	36%	100%
"Chariot(s)"	4/9	44	48%	100%
"Spear(s)"	5/9	55	76%	100%
Total	10/30	**Average: 35%**	**Average: 53%**	**Average: 100%**

Mahabharata and Hesiod, unsurprisingly, have little in common, being separate in genre and culture. Given such pronounced Near Eastern influence in Hesiod, they had overlap in only 6 of the 30 overall categories. For "spears", they did have one striking commonality: each contained exactly one adjective designating "length" and two designating "sharpness"; this one

point of similarity is the only reason their score is as high as it is, but both adjectives are to be expected when describing spears in general.

Table 12: Summary of adjective categories shared by Mahabharata and Hesiod

Word	**# Categories shared**	**% Categories shared**	**Percent in Mahabharata shared w/ Hesiod**	**Percent in Hesiod shared w/ Mahabharata**
"Arrow(s)"	1/12	8%	9%	100%
"Chariot(s)"	3/9	33%	4%	66%
"Spear(s)"	2/9	22%	43%	43%
Total	6/30	**Average: 20%**	**Average: 18%**	**Average: 69%**

Although Hesiod and the Rig Veda are linked by genre, both being texts primarily containing hymns to or about the gods, they exhibit no greater average percentage of shared adjective categories in the discourse of weaponry than do Hesiod and the Mahabharata. This, coupled with the Iliad and Hesiod's low score of 35% similarity, suggests that the similarities between the discourse of weaponry in the IE texts do originate primarily in their shared IE inheritance, not in their genre, which validates my second hypothesis. While cultural proximity surely fostered the similarity between the Mahabharata and its precursor, the Rig Veda, their total shared score was no closer than that of the two epics, and the total; the shared score between the two Greek texts was 24 points lower. These findings together support my fourth hypothesis, anticipating that Hesiod would bear fewer similarities to the other texts given its cultural differences.

Table 13: Summary of adjective categories shared by Rig Veda and Hesiod

Word	**# Categories shared**	**% Categories shared**	**Percent in Rig Veda shared w/ Hesiod**	**Percent in Hesiod shared w/ Rig Veda**

“Arrow(s)”	1/12	8%	15%	100%
“Chariot(s)”	4/9	44%	39%	100%
“Spear(s)”	1/9	11%	25%	29%
Total	6/30	**Average: 20%**	**Average: 26%**	**Average: 76%**

Pairwise sentence embeddings

The results from the noun-adjective analysis showcase trends on a poetic level, while the SentenceBERT analysis was meant to highlight possible narrative trends on the sentence level. For all four sets of the keyword-filtered sentences, I created a matrix of similarity scores for each non-repeating combination of sentences in the text pairs. For each of these instances, I calculated the maximum, range, and average cosine similarity scores, presented in Table 14 in descending order of maximum similarity score. I anticipated that while SentenceBERT would likely pick up on cultural similarities between related texts, it would also identify shared patterns between the epics that could point to narrative lineage.

Below is the sentence pair with the highest maximum cosine similarity score (0.72), also represented in Table 14 below:

Iliad: “and about his shoulders he cast his silver-studded sword of bronze and thereafter his shield great and sturdy and upon his mighty head he set a well-wrought helmet with horsehair crest and terribly did the plume nod from above and he took a valorous spear that fitted his grasp.”

Hesiod: “and he took his strong spear pointed with shining bronze and on his valiant head set a well-made helm of adamant cunningly wrought which fitted closely on the temples and that guarded the head of godlike heracles.”

These two sentences are clearly very similar in scope, with both referencing bronze weaponry and "wrought" helmets, signaling that SentenceBERT was very adept at identifying highly similar pairs of sentences between culturally related texts as hypothesized. However, not all sentence pairs that had especially high cosine similarity scores had content that showcased a meaningful pattern, upon closer inspection – some sentence pairs with high cosine scores were part of a text pairing that had a very large range (i.e., significant variability in cosine scores), and there was not a consistent numerical predictor of a sentence pair's likelihood to reveal a salient pattern. To this point, one of the most meaningful pairs of sentences had a similarity score that was nearly 0.2 units lower than the highest-scoring pair, but was still very salient:

> **Hesiod**: "so said the brighteyed goddess and swiftly got up into the car with victory and renown in her hands."
>
> **Rig Veda**: "dawn on her nobly-harnessed car the goddess awaking men to happiness approacheth."

These sentences capture the extremely rare phenomenon of a goddess commanding a chariot during wartime – a role almost exclusively reserved for men. This suggests that this typescene is written in a formulaic way, sharing similar syntactic patterns such that the SentenceBERT algorithm was able to pair them together as meaningfully similar out of thousands of combinations of sentences. This finding also suggests neither maximum cosine similarity or range is necessarily the most important gauge of an IE formula or shared connection between texts, and that none of the three metrics used can be individually considered the most informative. This takeaway is further corroborated by the fact that Mahabharata and Hesiod, the text pairing with the least historical similarity, had the third highest maximum cosine score of all eighteen text pairings.

While this outcome makes interpretation of the results difficult, it validated the idea that the selected texts were clearly all reasonably comparable, with all text combinations featuring very similar average similarity scores and covering subject matter that was verifiably similar enough to be used as a valid testing ground. It also confirmed the idea that computational analysis could unearth syntactic patterns in the fashion that Fenick (1968) identified - even rare ones like goddesses commanding chariots. Finally, we can see that the "battle"/war keyword category was linked with the highest maximum cosine scores regardless of text pairing, that the foot keyword category had mid-range maximum cosine scores regardless pairing, and the sun keyword category had the lowest maximum cosine scores regardless of text pairing, which suggests that there may be a pattern in similarity by keyword type that is worth exploring with more sophisticated statistical analyses.

Table 14: Max cosine similarity score pairs in descending order
Highlighted by shared text pair and shared keyword category

Text pair	Maximum pair cosine score	Range of cosine pair scores	Average pair cosine score
il_hesiod_war	0.7180619239807129	0.7971055507659912	0.31101462694209975
mb_rig_war	0.6899632215499878	0.8886285573244095	0.20955042712640673
mb_hesiod_war	0.689659833908081	0.8340269178152084	0.24718488893365081
mb_il_war	0.6853979229927063	0.8385511934757233	0.2667498648206918
hesiod_rig_war	0.6830722093582153	0.8112124055624008	0.1861921880888797
mb_il_foot	0.6522955298423767	0.7786441445350647	0.2330994627215821

il_rig_war	0.6408348083496094	0.7984336018562317	0.20519418716499405
mb_rig_foot	0.6373332738876343	0.7935846298933029	0.18221498194806432
il_hesiod_foot	0.6304384469985962	0.6304384469985962	0.2607068142007235
mb_hesiod_foot	0.615432620048523)	0.7749933451414108	0.21127900057450294
hesiod_rig_foot	0.6065730452537537	0.7630134522914886	0.1911331717625011
il_rig_sun	0.6029852032661438	0.6050003003329039	0.2864854947456105
mb_rig_sun	0.5899282693862915	0.6310000568628311	0.2662326659352317
il_rig_foot	0.5848109722137451	0.7042316198348999	0.21041807599063342
hesiod_rig_sun	0.5390960574150085	0.4402604103088379	0.3062189911933322
mb_il_sun	0.5373544692993164	0.4516788199543953	0.284059158767815
mb_hesiod_sun	0.5098788738250732	0.40359874814748764	0.2740823008740942
il_hesiod_sun	0.5009117126464844	0.31628501415252686	0.3404636918788865

Discussion

Noun-adjective analysis

Spears

Taken together, the evidence examined in this study suggests that: 1) in regards to poetic diction concerning spears, the Mahabharata was closer to the Iliad than it was to the Rig Veda, likely because of the relatively greater importance of battle in the epic narrative. However, 2), the two Greek texts resembled one another more closely than the two epics did, undoubtedly because of the importance of the spear in Greek warfare in the Bronze Age. Since the Mahabharata went on to be refined and added to over nearly 1000 years, it is not surprising that something as location- and trend-dependent as fighting styles evolved and changed. The Iliad is clearly the outlier, and the text in which spears likely grew in importance as an element of combat, rather than a text which reflects an IE norm which declined in India. Therefore, it is most productive here to analyze the degree to which the adjective-use pattern in the other texts gives an indication of the general outlines of the Iliad's spear-related discourse, but in a more nascent form.

The overall impression is that the Iliad continues an inherited IE pattern of referring to spears by their length, sharpness, and tendency to shine or glitter in combat, along with descriptions of their quantity in a combat situation (always a favored component of descriptions in the Mahabharata), and references to their shape. During the Mycenaean period and the Dark Age, the spear became the preeminent weapon of war in Greece (Kramer-Hajos (2016) speculates that swords were only used after the spears had been thrown and lost and group formations had fallen apart in battle), and in this milieu, references to the strength and dangerousness of them as weapons became commonplace. Finally, in the brutal materials-shortages of the Dark Age, when Hesiod was composing and the Homeric epics were assuming their final form, references to the raw materials of which a spear was crafted---especially to

bronze which became scarce and precious when tin imports from the ancient Near East were cut off---became an important part of the discourse.

Arrows

As a whole, the data on arrows offers a number of interesting and suggestive conclusions. Overall, the IE texts largely ascribe the same primary set of qualities to arrows, and not all of these are the most predictable features for which an arrow might be expected to be noted. The Iliad's discourse on arrows was far more closely affiliated with that of the Indic texts than with Hesiod, both in terms of the frequency with which arrows are used as weapons, and in the way they were described.

The Mahabharata applies a far greater diversity of adjectives to "arrow(s)" than any other text; 7% of its adjectives did not have a single analogue in the other texts. Other than the unique modifiers found in the Mahabharata, adjective usage with "arrow(s)" in the two epics occurs with the similar frequency (31% and 35%) and has an overall larger overlap in types of descriptors employed, than adjective usage between the Mahabharata and the Rig Veda. 100% of the categories of adjectives used in the Iliad are found in the Mahabharata. The majority of the adjectives applied to "arrow(s)" in both epics comes from the nine categories both utilize, and constitute the vast majority of the adjectives used. Four of those categories (arrowhead, materials, quantity, and wingedness) occur only in the epics: Iliad (34%) and Mbh (27.5%). The Mahabharata, while attaching modifiers to "arrow(s)" at roughly the same rate as the Iliad, ultimately does use a far wider variety of them, with many more shades and gradations of meaning.

The Mahabharata and the Rig Veda also shared significant overlap, in 8 categories, with 100% of the Rig Vedic adjectives for arrows coming from categories used by the Mahabharata

and 47% of the Mahabharata's adjectives coming from categories shared by the Rig Veda. The Iliad and the Rig Veda share surprisingly comparable, and similarly constrained, vocabularies with respect to arrows. 70% of the Rig Veda's categories and 67% of the Iliad's are shared. Though the bow-and-arrow is one of the oldest weapons, it retains consistent importance in Indo-European culture as the weapon of choice for the heroes whose primary quality is intelligence, such as Arjuna and Odysseus, and it was commonly used in bridal competitions (such as that employed in the Odyssey for Odysseus to win back Penelope) for both cultures. This shared tradition clearly retained some shared discourse as well.

Chariots

While the Indo-European texts used a wide variety of overlapping adjective modifiers for "chariot(s)" (and their usage patterns differed substantially from Hesiod's), they tended to use them with very different rates and distributions. This could certainly reflect Indo-European patterns of poetic diction relating to chariots which atrophied in some branches and were amplified in others. Of particular note: all three IE-descended texts (Rig Veda, Mahabharata, and the Iliad) overwhelmingly described chariots as beautiful, while the Hesiodic text did not. Moreover, these texts described chariots as beautiful while not ascribing the same aesthetic weight to spears or arrows. This, in tandem with all four texts referencing the chariot's utility in some way, might be evidence of the Indo-Europeans' pride in their chariots as symbols of the craftsmanship that allowed them to travel across such large swathes of land – or, could just as easily reflect the same marketing strategies that can be found in modern car ads, which often place more emphasis on a car's appearance than on being "well-wrought".

The chariot was to the Bronze Age what the car has been to the modern: while it has iconic associations with certain people and places, it is used throughout the world. The Indo-

Europeans likely invented the practice of bitting horses and the earliest spoked-wheel chariots have been found in steppe graves (Anthony, 2010), but the use of the chariot spread rapidly through Asia Minor as well, at first via IE migrations and then through the indigenous cultures there. Horse- and ox-drawn wagons seem to have been the primary means by which the Indo-Europeans accomplished their dispersal, but the chariot had a central place in IE heroic literature, which further backs the shared trends in the IE-descended texts.

Summary: Noun-adjective analysis

The frequency with which the various texts use the individual terms seems to relate in large part to cultural realities. Spears were the primary weapon of Greek epic warfare for example, so while the Iliad is one-eighth the size of the Mahabharata, it mentions spears nearly 18 times as often. In contrast, the Mahabharata mentions "arrow(s)" roughly 3.5 times as often as the Iliad. Chariots are used in both as the primary form of transportation, but the Iliad uses the term "chariot(s)" 1.21 times more frequently than the Indian epic, relative to its size. The discrepancy in occurrences may have to do with the fact that while the chariot was even more critical to Indic warfare than it was to Homeric, in the Greek epics heroes drove their own or other another's chariots, while the professional charioteers of the Indic epics are men of mixed caste and relatively low status; by this association, it is possible that the chariot itself was not seen as an accoutrement that brought particular glory to the warrior.[8]

While there may be a discrepancy in the use of the terms, both texts still describe them in very similar terms. Both epics assign adjectival modifiers at nearly the same rate: 10% for the

[8] This idea is supported by the fact that one of the very few chariots in the Mahabharata which is described in any detail is that of the hero Arjuna during the Bhagavad-Gita, at which point the god Krishna is serving as his charioteer.

Iliad and 9% for the Mahabharata, while the Rig Veda modifies 22% of its occurrences of "chariot(s)" and Hesiod assigns modifiers 53% of the time. This outcome supports the first hypothesis, that the epics will assign modifiers at similar rates, and the second hypothesis that the epics will retain vestiges of their IE diction, given shared patterns with the Rig Veda that were not present in Hesiod.

Pairwise Sentence Embeddings

While SentenceBERT was very useful for identifying similar pairs of sentences between all four texts, cosine similarity did not appear to directly correlate with presence of an identifiable IE formula in a similar sentence pair. Some of the inconsistency in cosine similarities ability to speak to IE formulas can be explained, however. This method was very successful at pointing out areas where the Mahabharata was imitating the Rig Veda (e.g., detailing a chariots splendor or a religious ritual); but when the topic shifted to battle, the Mahabharata discussed it far more frequently than the Rig Veda did, which accounts for the high maximum cosine score in this text pair and the simultaneously large range (i.e., large amount of variation in sentence pair similarity). Of note: culture may have been more influential than genre for SentenceBERT when identifying similar sentence pairs, given that the Hesiod-Rig combination did not score the highest in any of the three keyword categories, and both texts shared a religious valence.

That being said, given that the chosen texts had the potential to vary or relate on multiple levels , the high-ranking maximum cosine similarity scores could be explained by any of those three shared features, confounding interpretability. This prompts the need for more rigorous statistical analysis on these results in future iterations of this work.

Summary: Support for hypotheses

For the readers' convenience, here are the hypotheses listed once again:

H1: The Mahabharata and the Iliad (being in the same genre) will modify these war-related terms with adjectives at similar rates, i.e., both texts will likely call a chariot a "swift chariot" (vs. just "a chariot") or an arrow "a deadly arrow" (vs. just saying "an arrow") a similar percentage of the times these terms are mentioned.

As Table 15 below demonstrates, for "arrow(s)" and "chariot(s)" the rates of adjective application in the epic were far closer to one another than they were to the other two texts, with 31% and 35% respective rates for the first, and 10% and 9% rates for the second. "Spear(s)", being the outlier which dwindled in the Indic context and assumed more and more cultural importance in the Greek context, has a slightly greater divergence, at 31% and 23%, respectively, putting the Mahabharata's poetic diction for "spear(s)" more in line with the Rig Veda, a commonality which cultural factors made unsurprising. Within the Greek context, however, the adjectival modification of "spear(s)" had no cultural similarities at all, with the Iliad mentioning them more than three times as frequently (when adjusted for the difference in the size of the texts, and Hesiod assigning them adjective nearly 20% more often). Thus, the first hypothesis was largely supported.

Table 15: Noun modification frequencies across all four texts

Category	Iliad	Mbh.	Rig Veda	Hesiod
Arrows	[114 total] 36 w/adj.	[3184 total] 1,020 w/ adj.	[82 total] 20 w/ adj.	[8 total] 2 w/ adj.
% modified	31%	35%	24%	25%
Spears	[524 total] 165 w/ adj.	[30 total] 7 w/ adj.	[21 total] 4 w/ adj.	[14 total] 7 w/ adj.
% modified	31%	23%	19%	50%

Chariots	[256 total] 27 w/adj.	[1691 total] 156 w/adj.	[698 total] 144 w/adj.	[17 total] 9 w/adj.
% modified	10%	9%	22%	53%

H2: The two epics will apply similar classes and types of adjectives to the search terms, suggesting that even though they evolved in separate cultural contexts for some 500 to a thousand years, they retain traces of a shared poetic diction inherited from Indo-European Proto-epic.

For arrows, the epics shared 69% of the total adjective categories (Table 8). All of the Iliad adjective categories for arrows occurred in the Mahabharata as well, although 21% of the Mahabharata's adjectives were not used in the Iliad, an outcome that held true for chariots as well. Chariots and spears had overlapping categories applied in four out of nine (44%) and five out of nine (55%) categories, therefore averaging 56% shared adjective categories for each battle term. While spears were not nearly as prevalent in the Mahabharata, 100% of the modifiers applied to them were in categories shared with the Iliad. Overall, the Iliad had 89% of its adjective categories in common with the Mahabharata, and 80% of the Mahabharata's categories were found in the Iliad. Taken together, these results support the second hypothesis.

H3: I am expecting a shared trend in frequency of mentions of chariots in the epics (relative to their size), given that chariots were central to the Indo-Europeans, they took pride in their vehicles' craftsmanship and utility.

Some of the adjective category outcomes were surprising: contrary to what was expected, neither the Mahabharata nor the Iliad focused on chariots' utility. While this *was* a trait featured in all four texts (including the non-IE text), the Mahabharata and Iliad focused primarily on

chariots' beauty, which may also signify how important chariots were to them. This idea is supported by the fact that beauty was the only category that was shared by the epics and Rig Veda, the other text of IE descent. However, with regard to pure frequencies, the Iliad referenced chariots far more times than the Mahabharata did. This may be attributed to Iliad being comprised of more battle books than the Mahabharata, providing more opportunities for chariots to be mentioned – but even with this point considered, the Mahabharata would mention chariots 153 times to Iliad's 256, a sizable difference. Taken together, these results support the second hypothesis but discredit the third.

H4: The Hesiodic texts should exhibit marked differences from the three IE-descended texts. While the Hesiodic texts are written in Greek around the same time as the Homeric epics were reaching their final form, the Near Eastern influences that shaped them have been well-documented (M.L. West, 1997).

As indicated in Tables 8-13, the Hesiodic texts exhibited marked differences from the three IE-descended texts for descriptors related to arrows, chariots, and spears, with exceptions for arrows with ill-intent and the utility of chariots in battle. Given that the majority of adjective categories favored the argument for shared IE-inheritance between the epics, this hypothesis was largely supported. However, while the cross-cultural similarity between the Hesiod and Iliad and the Rig Veda and Mahabharata is to be expected, and has been accounted for to the best of my ability, it still acts as a confound when attempting to isolate the specific features that can be characterized as IE-descended instead of than culturally shared. The SentenceBERT result detected highly similar sentences within the Mahabharata and Hesiodic text pair, reflecting this blurring between trends that be attributed to genre or culture.

H5: Both epics will contain noun adjective pairs which are repeated many times. Formulaic diction is the Homeric characteristic which led to the recognition that it was orally composed and transmitted (Lord, 1973) and an important part of the Mahabharata's verbal style as well (Brockington, 1998).

This hypothesis was corroborated on almost every front (Tables 2-7), with the epics sharing several adjective categories as well as specific adjectives that were repeated. "Winged arrow", mentioned 3 times in the Iliad and 26 times in the Mahabharata, shared an Indo-European root, corroborating the idea that noun-adjective pairing analysis can reveal evidence of IE lineage in text.

Limitations and future work

While this was a novel and fruitful analysis, there were limitations to my work that are worth noting. First, translations were used in this study, not the original texts themselves. Dr. West bore this caveat in mind when selecting translations and using noun-adjective pairs in the analysis, but future work should run the NLP analyses on the original Sanskrit and Greek texts and identify adjectives and the SentenceBERT sentence pairs in their original languages. Second, more sophisticated analyses for interpreting the cosine similarity scores are required in order to tease apart patterns in maximum, average, and range cosine similarity and outcomes that can be attributed to shared inheritance, culture, temporal proximity, and genre. Third, a more robust computationally-based method should be identified to better categorize adjectives so that they do not need to be clustered by hand. Fourth, some of the sentences from the SentenceBERT analysis could theoretically have been double-counted, because they could have included keywords from multiple categories -- this issue should be rectified in future iterations of this study. Finally, despite the Stanford POS tagger being one of the most accurate part of speech taggers available,

it does not have perfect accuracy and uses pre-existing vocabulary databases to tag parts of speech in text. Future replications of this study should train a part of speech tagger on the existing text data to ensure better accuracy, instead of training on pre-existing corpora. Expanding this work to include other IE texts outside of Greece and India would be very exciting as well.

Conclusion

This novel study explored poetic and narrative similarities between four Greco-Aryan texts. It has contributed to the evidence that noun-adjective pairing analysis can help uncover IE patterns, and is the first study to my awareness that used SentenceBERT to uncover narrative similarities. Both methods have uncovered several promising trends, but have limitations that make interpreting some of the results challenging. This nascent project nonetheless shows much promise in using quantitative methods to analyze ancient texts, and would benefit from further statistical exploration in future iterations.

References

Adluri, V., & Bagchee, J. (2012). From Poetic Immortality to Salvation: Ruru and Orpheus in Indic and Greek Myth. *History of Religions*, *51*(3), 239–261. https://doi.org/10.1086/662191

Aggarwal, P. An Extravagant Depiction of the Human World: Through the characters in The Mahabharata and The Iliad.

Allen, N. J. (2000). Marriage by Capture. *The Journal of the Royal Anthropological Institute*, *6*(1), 135–135.

Allen, N. J. (2002). Mahābāhārata And Iliad: A Common Origin ? *Annals of the Bhandarkar Oriental Research Institute*, *83*, 165–177.

Allen, N. J. (2007). Śiva and Indo-European Ideology: One Line of Thought. *International Journal of Hindu Studies*, *11*(2), 191–207.

Allen, N. J. (2010). *Hephaestus and Agni: Gods and Men on the Battlefield in Greek and Sanskrit Epic*.

Allen, N. J. (2014). Heroes And Pentads: Or How Indo-European Is Greek Epic? *Bulletin of the Institute of Classical Studies*, *57*(1), 1–19.

Allen, N. J. (2016a). The common origin approach to comparing Indian and Greek philosophy. In R. Seaford (Ed.), *Universe and Inner Self in Early Indian and Early Greek Thought* (pp. 12–27). Edinburgh University Press. https://www.jstor.org/stable/10.3366/j.ctt1bgzdmh.7

Allen, N. J. (2016b). The King-Priest Quarrel in the Ādiparvan and the Iliad. *The Journal of Indo-European Studies*, *44*, 422–440.

Allen, N. J. (2019). *Arjuna-Odysseus: Shared Heritage in Indian and Greek Epic*. Taylor & Francis Group.

Alonso, F. W. (2008). Heracles In The Mahābhārata. *Rivista Degli Studi Orientali*, *81*(1/4), 73–101.

Alonso, F. W. (2015). India And Greece: Methods and Models of Comparison in the Mahābhārata And Greek Mythology. *Rivista Degli Studi Orientali*, *88*(1/4), 215–227.

Anthony, D. W. (1995). Horse, wagon & chariot: IE languages and archaeology. *Antiquity, 69*(264), 554. Retrieved from http://proxy.uchicago.edu/login?url=https://www.proquest.com/scholarly-journals/horse-wagon-chariot-IE-languages/docview/1293763139/se-2?accountid=14657

Anthony, D. W. (2010). *The horse, the wheel, and language: how Bronze-Age riders from the Eurasian steppes shaped the modern world*. Princeton University Press.

Anthony, D. W., & Ringe, D. (2015). The IE homeland from linguistic and archaeological perspectives. *Annu. Rev. Linguist.*, *1*(1), 199-219.

Arbman, E. (1922). *Rudra: Untersuchungen zum altindischen Glauben und Kultus*. Appelbergs boktryckeri aktiebolag.

Baldick, J. (1994). *Homer and the Indo-Europeans: Comparing Mythologies*. Bloomsbury Academic.

Bassett, S. E. (1922). On the Use of Two Spears in Homeric Warfare. *The Classical Journal*, *18*(2), 104–106.

Bhattacharji, S. (1988). Intruders Into The Pantheon: Śiva And Dionysos. *Annals of the Bhandarkar Oriental Research Institute*, *69*(1/4), 93–110.

Bouckaert R, Lemey P, Dunn M, Greenhill SJ, Alekseyenko AV, Drummond AJ, Gray RD, Suchard MA, Atkinson QD. 2012 Mapping the origins and expansion of the IE language family. Science 337, 957–960. (doi:10.1126/science.1219669)

Brockington, J. L. 1998. *The Sanskrit Epics*. Brill.

Budziszewska, N. (2017). The Self-Chariots of Liberation: Platos Phaedrus, The Upaniṣads, And The Mahābhārata in Search Of Eternal Being. *Philosophy East and West*, *67*(2), 318–351.

Celtiques, C. C. U.-A. des É. (n.d.). Jean Haudry: Courtisanes. *Journal Asiatique 303.2*.

Chang W, Cahtcart C, Hall D, Garrett A. 2015 Ancestry-constrained phylogenetic analysis supports the Graeco-Aryan steppe hypothesis.

Chaturvedi, A. (2016). Harmonia and ṛtá. In R. Seaford (Ed.), *Universe and Inner Self in Early Indian and Early Greek Thought*. Edinburgh University Press.

Chew, K. (2011). Eyeing Epiphanies in Greek, Latin, and Sanskrit Texts. *Phoenix*, *65*(3/4), 207–237.

Clackson, J. (2007). *IE linguistics: an introduction*. Cambridge University Press.

Clay, J. S. (2011). The Homeric Hymns. In *A New Companion to Homer* (pp. 489-507). Brill.

de Jong, J. W. (1985). The Over-Burdened Earth in India and Greece. *Journal of the American Oriental Society*, *105*(3), 397–400. https://doi.org/10.2307/601515

Da Silva, S. G., & Tehrani, J. J. (2016). Comparative phylogenetic analyses uncover the ancient roots of IE folktales. *Royal Society open science*, *3*(1), 150645.

Dexter, M. R., & Polomé, E. C. (Eds.). (1997). *Varia on the Indo-European past: Papers in memory of Marija Gimbutas*. Institute for the Study of Man.

Doniger, W. (1997). Sita and Helen, Ahalya and Alcmena: A Comparative Study. *History of Religions*, *37*(1), 21–49.

Doniger, W. (1999). *Splitting the Difference: Gender and Myth in Ancient Greece and India*. University of Chicago Press.

Drews, R. (1994). *The Coming of the Greeks: Indo-European Conquests in the Aegean and the Near East*. Princeton University Press.

Drews, R. (1996). *The End of the Bronze Age: Changes in Warfare and the Catastrophe ca. 1200 B.C.* Princeton University Press.

Drews, R. (2008). *Early Riders: The Beginnings of Mounted Warfare in Asia and Europe*. Routledge.

Drews, R. (2019). *Militarism and the Indo-Europeanizing of Europe*. Routledge.

Duckworth, G. E. (1961). Turnus and Duryodhana. *Transactions and Proceedings of the American Philological Association*, *92*, 81–127. https://doi.org/10.2307/283804

Edmunds, L. (2020). *Stealing Helen: The Myth of the Abducted Wife in Comparative Perspective*. Princeton University Press.

Fenik, B. (1968). *Typical Battle Scenes in the Iliad: Studies in the narrative techniques of Homeric battle description* (Vol. 21). F. Steiner.

Fries, A. (2016). Indo-European Night Raid Revisited. *Journal of Indo-European Studies*, *44*, 289–324.

Gangopadhyay, B. K. Historicity of the Mahabharata and the most probable date of the Kurukshetra war.

Garbutt, K. (2006). An Indo-European Night Raid? *The Journal of Indo-European Studies*, *34*(1-2 (Spring/Summer)), 183–200.

Grégoire, H., Goossens, R., & Mathieu, M. (1950). *Asklépios, Apollon Smintheus et Rudra. Études sur le dieu à la taupe et le dieu au rat dans la Grèce et dans lInde par Henri*

Grégoire avec la collaboration de R. Goossens et de M. Mathieu. Mémoires de lAcadémie royale des Sciences, des Lettres et des Beaux-Arts de Belgique.

Gresseth, G. K. (1979). The Odyssey and the Nalopākhyāna. *Transactions of the American Philological Association (1974-), 109*, 63–85. https://doi.org/10.2307/284049

Grohmann, J. V. (1862). *Apollo Smintheus und die Bedeutung der Mäuse in der Mythologie der Indogermanen*. J.G. Calve. http://archive.org/details/bub_gb_tT0CAAAAQAAJ_2

Hiltebeitel, A. (1990). *The Ritual of Battle*. SUNY Press.

Jamison, S. W. (1994). Draupadí on the Walls of Troy: "Iliad" 3 from an Indic Perspective. *Classical Antiquity*, *13*(1), 5–16. https://doi.org/10.2307/25011002

Jamison, S. W. (1999). Penelope and the Pigs: Indic Perspectives on the "Odyssey." *Classical Antiquity*, *18*(2), 227–272. https://doi.org/10.2307/25011102

Kazanas, N. (2001). Archaic Greece and the Veda. *Annals of the Bhandarkar Oriental Research Institute*, *82*(1/4), 1–42.

Kramer-Hajos, Margaretha. 2016. Mycenaean Greece and the Aegean World: Palace and Province in the Late Bronze Age. Cambridge University Press.

Lincoln, B. (1975). The Indo-European Myth of Creation. *History of Religions*, *15*(2), 121–145.

Lincoln, B. (1976). The Indo-European Cattle-Raiding Myth. *History of Religions*, *16*(1), 42–65.

Lincoln, B. (1986). *Myth, Cosmos, and Society: Indo-European Themes of Creation and Destruction*. Harvard University Press.

Littleton, C. S. (1980). The Problem That Was Greece: Some Observations on the Greek Tradition from The Standpoint of the New Comparative Mythology. *Arethusa*, *13*(2), 141–159.

Lord, Albert B. 1973. *The Singer of Tales*. Atheneum.

Magnone, P. (2016). Soul chariots in Indian and Greek thought: Polygenesis or diffusion? In R. Seaford (Ed.), *Universe and Inner Self in Early Indian and Early Greek Thought* (pp. 149–167). Edinburgh University Press. https://www.jstor.org/stable/10.3366/j.ctt1bgzdmh.16

Mallory, J. P. (1992). In Search of the IEs/Language, Archaeology and Myth. *Praehistorische Zeitschrift*, *67*(1), 132-137.

Mallory, J. P., & Adams, D. Q. (2006). *The oxford introduction to proto-IE and the proto-IE world*. Oxford University Press on Demand.

McGrath, K. (2019). *Vyāsa Redux: Narrative in Epic Mahābhārata*. Anthem Press. https://doi.org/10.2307/j.ctvjz836x

Metzger, B. M. (1946). Trends in the Textual Criticism of the Iliad, the Mahabharata, and the New Testament. *Journal of Biblical Literature*, *65*(4), 339–352. https://doi.org/10.2307/3262154

Nikolopoulou, K. (2007). Feet, Fate, and Finitude: On Standing and Inertia in the Iliad. *College Literature*, *34*(2), 174–193. https://doi.org/10.1353/lit.2007.0020

Nomikos, N. (2018). Injuries in the Greek epics of Homer. *Chinese journal of traumatology*, *21*(2), 109-112.

Panegyres, K. (2017). Ὀρεϊ νιφόεντι ἐοικώς: Iliad 13.754-755 Revisited. *Mnemosyne*, *70*(3), 477–487.

Paul, A., & Das, D. (2017, September). Identification of Character Adjectives from Mahabharata. In *RANLP* (pp. 569-576).

Petrosyan, A. (2017). Proto-Iliad in the Context of Indo-European Mythology. In P. S. Avetisyan & Y. H. Grekyan (Eds.), *Bridging Times and Spaces: Festschrift in Honour of Gregory E. Areshian on the Occasion of His Sixty-Fifth Birthday*. Archaeopress Publishing Ltd.

Platte, Ryan. 2017. *Equine Poetics*. Hellenic Studies Series 74. Washington, DC: Center for Hellenic Studies.

Pronk, T. (2009). Sanskrit (v)ṛṣabhá-, Greek ἄρσην, ἔρσην: The spraying bull of Indo-European? *Historische Sprachforschung / Historical Linguistics*, *122*, 170–181.

Properzio, P. (2009). The Ramayana And The Odyssey: Kindred Epics Of India And Greece. *The Classical Outlook*, *86*(3), 89–92.

Pugazhendhi, D. (2021). *Greek, Tamil and Sanskrit: Comparison between the Myths of Herakles (related with Iole and Deianira) and Rama in Hinduism*. *8*(1), 28.

Puhvel, J. (1970). *Myth and Law Among the Indo-Europeans: Studies in Indo-European Comparative Mythology*. University of California Press.

Renfrew C. Archaeology and language: the puzzle of IE origins. J. Cape; London: 1987. p. xiv.p. 346. [8] p. of plates. (He was the main opponent of David Anthony, but according to a review I read yesterday, he has now backed down)

REVESZ, P. Z. A Comparative Analysis of Hungarian Folk Songs and Sanskrit Literature Using Motif Similarity Matrices.

Rudiger Schmidt, *Dichtung und Dichtersprache in indogermanischer Zeit* (1967)

Saunders, K. B. (1999). The wounds in Iliad 13-16. *The Classical Quarterly*, *49*(2), 345-363.

Schmitt, R. (1967). *Dichtung und Dichtersprache in indogermanischer Zeit*. Harrassowitz.

Schmitt, R. (1968). *Indogermanische Dichtersprache.* Wissenschaftliche Buchgesellschaft.

Seely, C. B. (1988). Homeric Similes, Occidental and Oriental: Tasso, Milton, and Bengals Michael Madhusudan Dutt. *Comparative Literature Studies*, *25*(1), 35–56.

Sick, D. H. (2004). Mit(h)ra(s) and the Myths of the Sun. *Numen*, *51*(4), 432–467.

Skjærvø, P. O. (1997). Eastern Iranian Epic Traditions III: Zarathustra and Diomedes–an Indo-European Epic Warrior Type. *Bulletin of the Asia Institute*, *11*, 175–182.

Smith, J. D. (1999). Winged Words Revisited: Diction and Meaning in Indian Epic. *Bulletin of the School of Oriental and African Studies, University of London*, *62*(2), 267–305.

Stoneman, R. (2019). *The Greek Experience of India: From Alexander to the Indo-Greeks*. Princeton University Press. https://doi.org/10.2307/j.ctv3znwg5

Suter, A. (1987). Aphrodite/Paris/Helen: A Vedic Myth in the Iliad. *Transactions of the American Philological Association (1974-)*, *117*, 51–58. https://doi.org/10.2307/283958

Swann, D. L. (1969). Indian and Greek Drama: Two Definitions. *Comparative Drama*, *3*(2), 110–119.

Van Der Pijl, K. (2010). *The Foreign Encounter in Myth and Religion: Modes of Foreign Relations and Political Economy, Volume II*. Pluto Press. https://doi.org/10.2307/j.ctt183h05v

Walker, H. J. (2007). The Greek Aśvins. *Annals of the Bhandarkar Oriental Research Institute*, *88*, 99–118.

Watkins, C. (2001). *How to Kill a Dragon: Aspects of Indo-European Poetics*. Oxford University Press.

West, E. B. (2005). An Indic Reflex of the Homeric Cyclopeia. *The Classical Journal*, *101*(2), 125–160.

West, E. B. (2006). The Goddess Takes the Reins: Diomedes Aristeia and Bhisma and Ganga in the Mahabharata. *Studia Indo-Europaea, 3,* 237–258.

West, E. B. (2009). Married Hero / Single Princess: Homers Nausicaa and the Indic Citrangada. *Journal of Indo-European Studies, 37*, 214–224.

West, E. B. (2010). A Quartet of Graeco-Aryan Demi-goddesses: Leukothea, Eidothea, Ulupi and Varga. *Journal of Indo-European Studies, 38*, 1–25.

West, E. B. (2014). Circe and Calypsos Indic Sister; The Odyssey and Graeco-Aryan Proto-Epic. *Journal of Indo-European Studies, 42*, 144–174.

West, E. B. (2016). Nausicaa and Iphthime: The Dark Side of the Woman at the Well. *Journal of Indo-European Studies, 44*, 494–519.

West, M. L. 1997. *The East Face of Helicon : West Asiatic Elements in Greek Poetry and Myth: West Asiatic Elements in Greek Poetry and Myth*. Clarendon Press.

West, M. L. (2007). *Indo-European Poetry and Myth*. OUP Oxford.

Appendix

Spears

Table 2a: Adjective categories shared by all four texts for "Spear(s)"

Category	Iliad	Mahabharata	Rig Veda	Hesiod
length	long: 29 far-shadowing: 21 50 30%	short: 1 long: 1 2 28%	deep-reaching: 1 1 25%	long:1 long:1 2 28%

Table 2b: Adjective categories shared by Epics and Hesiod for "Spear(s)"

Category	Iliad	Mahabharata	Rig Veda	Hesiod
sharpness	sharp: 30 sharp-pointed:1 keen: 1 32 19%	keen-pointed: 1 1 14%	0	sharp:1 1 14%

Table 2c: Adjective categories shared by Epics and Rig Veda (IE) for "Spear(s)"

Category	Iliad	Mahabharata	Rig Veda	Hesiod
brightness	bright: 19 polished: 1 20 12%	bright: 1 blazing:1 2 28%	glittering: 2 shining: 1 3 75%	0

Table 2d: Adjective categories shared by the Epics for "Spear(s)"

Category	Iliad	Mahabharata	Rig Veda	Hesiod

quantity	many: 1 1 .6%	numberless: 1 1 14%	0	0
shape	two-edged: 6 6 3%	long-handled: 1 1 14%	0	0

Table 2e: Adjective categories shared by Iliad and Hesiod for "Spear(s)"

Category	**Iliad**	**Mahabharata**	**Rig Veda**	**Hesiod**
Dangerousness	monstrous: 1 terrible: 1 2 1%	0	0	deadly:1 1 14%
material	ashen: 12 Pelian-ash: 2 8% bronze-shod: 4 bronze-tipped: 4 bronze-barbed: 1 5% 23 13%	0	0	brazen:2 2 28%
strength	mighty: 16 16 9%	0	0	strong:1 1 14%

Table 2f: Adjectives contained only in Iliad for "Spear(s)"

Category	**Iliad**	**Mahabharata**	**Rig Veda**	**Hesiod**

general good qualities	valorous: 4 goodly: 4 good: 2 great: 1 straight-flying: 1 wind-nurtured: 1 13 7%	0	0	0

Arrows

Table 4a: Adjectives contained only in Mahabharata for "Arrow(s)"

Category	**Iliad**	**Mahabharata**	**Rig Veda**	**Hesiod**
Miscellaneous:	0	Fiery: 4 fire-mouthed: 1 unpoisoned: 2 sky-ranging: 2 thick: 2 tinted: 1 adamantine: 1 steady: 1 yellowish: 1 heavy: 1 ceaseless: 1, far-reaching: 1 blood-dyed: 1 ray-like: 1 well-tempered: 1 long: 35 short: 12 small: 4 72 (7%)	0	0

Table 3b: Adjective categories shared by the Epics for "Arrow(s)"

Category	Iliad	Mahabharata	Rig Veda	Hesiod
1. Description of Arrowhead	bronze-tipped: 2 three-barbed: 2 long-barbed 1 notched:1 6 (17%)	broad-headed: 95 crescent-shaped: 20 razor-headed: 4 calf-toothed-headed: 4 horse-shoe-headed: 3 small-headed: 1 spear-headed: 1 broad-faced: 1 barbed:6 bearded: 1 136 (14%)	0	0
2. materials	golden: 2 2 (5%)	golden: 2 gold-decked: 3 wooden: 1 iron:6 12 (1%)	0	0
3. quantity	many: 1	many: 62 countless: 18 innumerable: 15 single:1 numerous: 5 numberless: 4 inexhaustible: 2 immeasurable: 1 few: 1	0	0

	1 (3%)	109 (11%)		
4. winged	winged: 3 3 9%	winged: 26 gold-winged: 2 four-winged: 1 fierce-winged: 1 30 (3%)	0	0

Table 4c: Adjective categories shared by the Epics and Rig Veda for "Arrow(s)"

Category	**Iliad**	**Mahabharata**	**Rig Veda**	**Hesiod**
5. speed	swift: 5 swift-falling: 1	swift: 3 swiftly-coursing: 5 shooting: 3 swift-flying: 1 swift-going: 1	swiftly-flying: 1 swift: 1	0

	6 17%	12 (1%)	2 10%	
6. sharpness	Sharp-piercing:1 Keen:1 Sharp: 1	sharp: 134 sharp-pointed: 14 keen: 87 keen-edged: 32 razor-faced: 14 keen-pointed: 4 whetted: 49 sharp-whetted: 1 stone-whetted: 1 sharpened: 6 sharp-edged: 2 deep-piercing: 1 all-piercing: 1 heart-piercing: 1 pointed: 2	keen: 2 sharpened: 1 sharp-pointed: 1 pointed: 1	
	3 8 %	349 (34%)	5 25%	

7. fletching	feathered: 1 1%	feathery: 1 plumed: 1 2 (.1%)	feathered: 1 1 5%	

Table 4d: Adjective categories shared by Epics and Rig Veda (IE) for "Arrow(s)"

Category	**Iliad**	**Mbh.**	**Rig Veda**	**Hesiod**
"virtuous" qualities	gentle: 1 1 3%	pure: 1 < .001%	heavenly: 1 bright: 1 lofty: 1 3 15%	0

Table 4e: Adjective categories shared by Mahabharata and Rig Veda for "Arrow(s)"

Category	**Iliad**	**Mahabharata**	**Rig Veda**	**Hesiod**
might & performance	0	excellent: 18 mighty: 10 powerful: 2 thunderlike: 1 strong 1 invincible: 1 formidable: 1 straight: 133 straight-going: 4 straight-coursing: 1	mighty: 1 heavenly: 1 flashing:1	0

		172 17%	3 10%	
attractiveness	0	beautiful: 6 bright: 5 blazing:18 well-adorned: 2 well-furnished: 1 good-looking: 2 well-looking:1 celestial: 2 31 3%	bright: 1 well-laid: 1 2 10%	0
aim	0	well-aimed: 1 well-shot: 2 3 .2%	well-directed: 1 ineffectual: 1 2 10%	0

Table 4f: Adjective categories shared by all four texts for “Arrow(s)”

Category	**Iliad**	**Mahabharata**	**Rig Veda**	**Hesiod**

ill-intent or cruelty	evil: 2 stinging: 2 bitter 9	fierce: 38 terrible: 33 blood-drinking: 5 Fatal: 4 impetuous: 2 cruel: 1 deadly: 2 maddening: 1 death-dealing: 2 frightful: 1 Mangling:1 cleaving:1	impetuous: 1 threatening: 1 insatiate: 1	chilling: 1 Grievous:1
	13 36%	91 9%	3 15%	2 100%

Chariots

Table 6a: Adjective categories shared by all four texts for Chariots(s)

Category	**Iliad** 256 total 27 w/adj. 10%	**Mahabharata** 1691 total 156 w/adj. 9%	**Rig** 698 total 144 w/adj. 22%	**Hesiod** 17 total 9 w/adj. 53%
Quality of Construction	well-built: 2 well-wrought: 1 3 11%	well-built: 1 well-protected: 1 2 1%	well-yoked: 1 well-harnessed: 1 nobly-harnessed: 1 3 2%	well-made: 1 well-woven: 1 richly- wrought: 1 3 34%
Speed	swift: 2	quickly-moving: 3 swift: 1	swift: 4 rapid: 3 swift-moving: 1 swiftly-racing: 1 winged: 1	fleet: 2

	2 7%	4 2.5%	10 7%	2 22%
Shape & Form	jointed: 4 curved: 2 wheeled:1	Decked:1	three-wheeled: 3 triple: 3 team-drawn: 2 seven-wheeled: 2 broad: 1 yoked:1 harnessed:1 one-wheeled: 1 six-spoked: 1 wheel-less: 2 wide-yoked: 1 triple-seated: 1 capacious: 1 broad-wheeled: 1 Bay-drawn: 1 high: 1	jointed: 1 curved: 1
	7 26%	1 .5%	23 16%	2 22%

Table 6b: Adjective categories shared by Iliad, Rig Veda, and Hesiod for Chariots(s)

Category	**Iliad**	**Mahabharata**	**Rig Veda**	**Hesiod**
Rolling & Wheels	well-wheeled: 1	0	easy: 5 lightly-rolling: 5 good: 3 light-rolling:1 rolling: 2 well-rolling: 1 well-wheeled: 1 terrific: 1 light: 2	smooth-wheeled : 1 Well-wheeled: 1
	1 3%		21 14 %	2 22%

Table 6c: Adjective categories shared by the Epics and Rig Veda (IE) for Chariots(s)

Category	Iliad	Mahabharata	Rig Veda	Hesiod
Beauty	beauteous: 5 polished: 2 fair: 2 gleaming: 2 well-plaited: 2 inlaid: 1 14 52%	splendid: 3 beautiful: 10 excellent: 35 flowery: 4 bright: 4 celestial: 19 fine: 1 variegated: 1 incomparable: 1 blazing:2 wonderful: 2 glorious: 1 resplendent: 2 lotus-hued: 1 heavenly: 1 handsome: 1 88 57%	refulgent: 7 splendid: 6 bright: 4 wondrous: 3 radiant: 3 famous: 2 new: 2 newly-fashioned: 1 heavenly: 1 beauteous: 1 celestial: 1 lovely: 1 all-lovely: 1 far-refulgent: 1 tall: 2 lofty: 3 Godlike:1 40 28%	0

Table 6d: Adjective categories shared by Mahabharata and Rig Veda for Chariots(s)

Category	Iliad	Mahabharata	Rig Veda	Hesiod
Golden	0	golden: 16 gold-decked: 2 18 11.5%	golden: 11 golden-coloured: 1 gold-yoked: 1 golden-seated: 1 14 10 %	0
Strength and Might	0	large: 6 mighty: 4 great: 14 powerful: 1 triumphant: 1 formidable: 1 well-equipped: 1 victorious: 3 terrible: 2	mighty: 6 powerful: 1 strong: 1 strong-horsed: 1 inviolable: 1 immortal: 1 strength-displaying: 1 awful: 1 ever-conquering: 1	0

		33 21%	Conquering 15 10%	
exhibition of wealth	0	costly: 3 superior: 1 4 2.5%	wealth-fraught: 1 treasure-laden: 1 treasure-bringing: 1 booty-seeking: 1 prosperous: 1 spoil-seeking: 1 6 4%	0
miscellaneous	0	Sable: 2 White: 2 Iron-mace:1 Heavy:1 6 4%	noble: 2 word-yoked: 1 honey-bearing: 1 eloquent: 1 hero-bearing: 1 helpful: 1 best-bearing: 1 blissful: 1 early-harnessed: 1 Spirit-fashioried:1 Rattling:1 12 8%	0