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Research Article

Iliad, *Odyssey*, and statistics

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Abstract

For centuries, the Homeric Question has fuelled fierce debate among scholars. The Homeric epics are widely regarded as having their origins in the Late Bronze Age, with oral transmission continuing until a final redaction in the eighth to second century BCE.
The question of whether a single poet wrote both *The Iliad* and *The Odyssey*, the time and place in which Homer(s) worked and lived, and the circumstances of the poems' final composition are still subjects of discussion.
In the present paper, a fairly simple statistical χ^2 analysis has been carried out to evaluate the frequency of the keywords related to metals and weapons, which are mainstays of the material culture of this ancient period.
A thorough examination of *The Iliad* discloses a pronounced predominance of the keyword 'bronze', exhibiting a higher frequency in *The Iliad* than in *The Odyssey*. On initial observation, the prevalence of dominance appears to be a consequence of the warlike nature of *The Iliad*. Notwithstanding, a significant dominance endures even when the intrinsic disparities between the two poems are taken into account and suitably adjusted.
This remarkable discrepancy suggests the potential for distinct authorship, editorial involvement, or redaction locations for *The Iliad* and *The Odyssey*.

Keywords: authorship; contingency analysis; Homeric Question; *Iliad*; *Odyssey*

Introduction

Since antiquity, scholars have debated the Homeric poems and their historicity. Initially, the attribution of authorship to Homer (as 'the master poet') was more extensive, encompassing the entire Epic Cycle, and even extending to the Theban epics during the pre-classical era (Nagy, 1996). In the centuries that followed, the conception of Homeric authorship underwent a narrowing of focus, centring exclusively on *The Iliad* and *Odyssey*. Concurrently, the remaining poems of the Epic Cycle were ascribed to a range of authorship.

Aristotle, in the fourth century BCE, had already evidenced fundamental differences between *The Iliad*, a 'simple story turning on calamity', and *The Odyssey*, a 'complex story . . . turning on character' (Aristotle, 1459b). In the Hellenistic period, the hypothesis that the author of *The Iliad* was not the same as the author of *The Odyssey* was advanced by subsequent scholars, known as Chorizontes (separators). Among them, Xenon and Hellanicus (No Author listed, 1827), two grammarians of the age of the Alexandrian critics, proposed that Homer was the author of *The Iliad*, while a different poet was responsible for the composition of the later *Odyssey*, as reported in the Proclus' *Vita Homeri* (No Author listed, 1827). This theory was met with significant opposition from the contemporary mainstream, particularly from Aristarchus of Samothrace (Britannica, The Editors of Encyclopaedia, 1910–1911; Montanari, 1976). Consequently, for many centuries thereafter, the authorship of both *The Iliad* and *The Odyssey* was attributed to a single Homer.

The modern Homeric Question can be traced back to the work of three scholars, from 1664 to 1744: the French playwright and theorist François Hédelin, abbot of Aubignac; the British classicist Richard Bentley; and the Italian historian and philosopher Giambattista Vico. These scholars advanced three contentions pertaining to the authorship of *The Iliad* and *Odyssey*. Firstly, that Homer never existed (Hédelin, 1715). Secondly, that the poems were composed orally by many generations of rhapsodes (Bentley, 1713). And thirdly, that the Homeric poetry was the work of multiple authors (Vico, 1744). The Swiss philosopher Jean Jacques Rousseau evidenced the problem of the Homeric writing (Rousseau, 1761), and both Vico and Rousseau underlined the importance of the oral creativity over the negative influence of writing on poetry (Vico, 1744; Rousseau, 1761). The Irish scholar and antiquarian Robert Wood explicitly anticipated the oralist theory in 1775 (Wood, 1775).

The French scholar Jean Baptiste Gaspard d'Ansse de Villoison rediscovered and published the tenth-century Venetus A codex in 1788 (d'Ansse de Villoison, 1788). Then, in his prolegomena, published in 1795, the German classicist Friedrich August Wolf demonstrated the limits of what could be known about Homer (whether he ever existed) and his work (Wolf, 1795). Wolf identified the early oral transmission of the Homeric poems as the primary source of early variants (Grafton et al., 1985), asserting that an original text was not recoverable (Wolf, 1795).

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This served to perpetuate the so-called Homeric Question for a period of more than two centuries, with scholars divided into two groups: Analysts and Unitarians. The former group asserted that *The Iliad* and *Odyssey* could not be the work of the same author but a sort of patchwork composed by many singer–poets. The latter group claimed a single authorship primarily on the basis of its substantial artistic unity; they viewed the Homeric texts as a layered but substantially uniform work of a 'master poet'. The above mentioned perspective was substantiated by the findings of a first wave of statisticians, who corroborated the single authorship of both poems through their computational analyses, in the years between 1919 and 1972 (Scott, 1919; Shewan, 1925; Jones and Gray, 1972).

The seminal contribution of US scholars Milman Parry and Albert Lord in the 1930s led to the development of the oral-formulaic concept, which represented a watershed in the Homeric studies. In the latter half of the twentieth century, the Oralist faction emerged under the assumption that these texts, derived from an oral tradition, originated 'in performance', irrespective of the number of 'Homers' (Duè and Marks, 2020).

Following the success of the Oralist faction, the former Analysis theory became obsolete, thus paving the way for the emergence of the Neo Analytic theory. The Unitarian thesis, however, emerged to a lesser extent.

In the contemporary era, scholars are exhibiting a greater degree of divergence in their opinions than has been observed at any time in the past.

The extant literature on the subject identifies three broad factions: the first, the last Unitarians (or Neo Unitarians in the words of Gregory Nagy), who claim a single author – Homer – for both *The Iliad* and *Odyssey*, welcome the idea of an oral Homer (Dalby, 2007); the second, the Neo-Analysts who, in spite of the name, are a sort of Unitarian movement (chiefly represented by the late Martin Litchfield West) who view one literate poet composing the texts with the help of writing, although influenced by earlier oral hymns, for *The Iliad* ('P' in West's words), and another for *The Odyssey* ('P^{OD}' in West's words) (West, 2011); the third, the Oralists (Parryists or followers of Parry and Lord), are represented mostly by the *prolixa* scientific production of the Center for Hellenic Studies (Washington DC) group. It is evident that Pache (sadly deceased in 2022), Dué, González, Bird, and others concur with the Nagy's perspective on the evolutionary transmission of Homeric poetry, from oral tradition to written texts. The five distinct, consecutive periods under consideration span from the early second millennium BCE to the middle second century BCE (with the completion of Aristarchus' editorial work at the Library of Alexandria) (Nagy, 2003). Furthermore, they concur with the multiple authorship genesis of Homeric poetry, irrespective of the number of 'Homers'.

Eventually, a small and variegated group of scholars, who can be designated as neo-Statisticians, advanced the same concept of multiple authorship through their more or less complex approaches, which are founded on numerical analysis (Fasoi et al., 2021; Bozzone and Sandell, 2021; Dedovic, 2022; Pavlopoulos and Konstantinidou, 2023). The utilisation of statistical methodologies in the evaluation of literary works has been the subject of analysis (Beierle et al., 2017).

The present study adopts a simple statistical approach with the intention of evaluating the frequency of specific keywords within the corpus of either poem. The keywords were selected to investigate both metals and weapons (specified below) that are frequently referenced in the Homeric verses.

The objective of the present study was to ascertain the frequency with which these keywords are mentioned in the texts. The aim was straightforward: to determine any potential discrepancies, if indeed there are any, between the two Homeric poems.

It is imperative to consider the intrinsic disparity between *The Iliad*, a war poem, and *The Odyssey*, a post-war poem. This distinction necessitates some degree of adjustment to ensure a comprehensive, unbiased, and accurate analysis.

The present investigation focused on the numerical disparities of the terms 'bronze' and 'iron' in *The Iliad* compared with *The Odyssey*. The assessment of such terms within the Homeric poems is not a novel concept. As early as the beginning of the last century, Andrew Lang published a thorough evaluation of the two metals (Lang, 1906) (actually, only iron is a metal, while bronze is an alloy [Britannica, The Editors of Encyclopaedia, 2004] of copper and tin). His study, which was both detailed and exhaustive, examined the use, the meaning, and the presence of both commodities in the Homeric poetry. Iron emerged as the most employed metal for tools and implements, while bronze was used for weapons: " . . . as a matter of certain fact, the swords, and spears, of Homer's warriors are invariably said by the poet to be of bronze, not of iron, in cases where the metal of the weapons is specified" (Lang, 1906). The kings and heroes of that world were rich in gold and iron, though they trusted only swords and spears forged from bronze (Lang, 1906).

Should a statistical significance be found between the frequencies of these terms in *The Iliad* compared with *The Odyssey*, an objective difference would be revealed between the two poems.

Methods

The texts of *The Iliad* and *Odyssey* were analysed for the frequency of occurrence. The texts examined are widely accessible throughout the web: these include *The Iliad* (Homer, 1924), and *The Odyssey* (Homer, 1919), translated by Augustus T. Murray, all available through the Theoi Classical Text Library (https://www.theoi.com/Library.html).

The differing nature of the two poems must be considered, before any analysis is performed. *The Iliad* tells the story of a warrior's wrath *during* the war, whereas *The Odyssey* chronicles the journey home of a sailor *after* the war. It is inevitable that the crude frequency of the weapons will reveal noticeable but obvious differences.

The selected keywords are:

Metals: bronze, iron, gold, silver, copper, brass, and steel.

Weapons: spear, shield, armour, arrow, sword, axe, greaves, helmet, and club.

Metals were selected for their technological properties, which can be used to trace the temporal differences in the events described in the poems. The primary rationale behind the enumeration of weaponry pertained to the exclusion of confounders, a necessity dictated by the discernible warlike nature of *The Iliad* in contrast to the predominantly post-war milieu depicted in *The Odyssey*.

It appears that copper, brass, and steel are outliers, with each term being represented on no more than two occasions. It is important to note that all keywords were evaluated in the original Greek text (Homer, 1924; Homer, 1919), in addition to the English translation. It should be noted that the original terms 'bronze' and 'iron' were occasionally translated in English as copper and brass,

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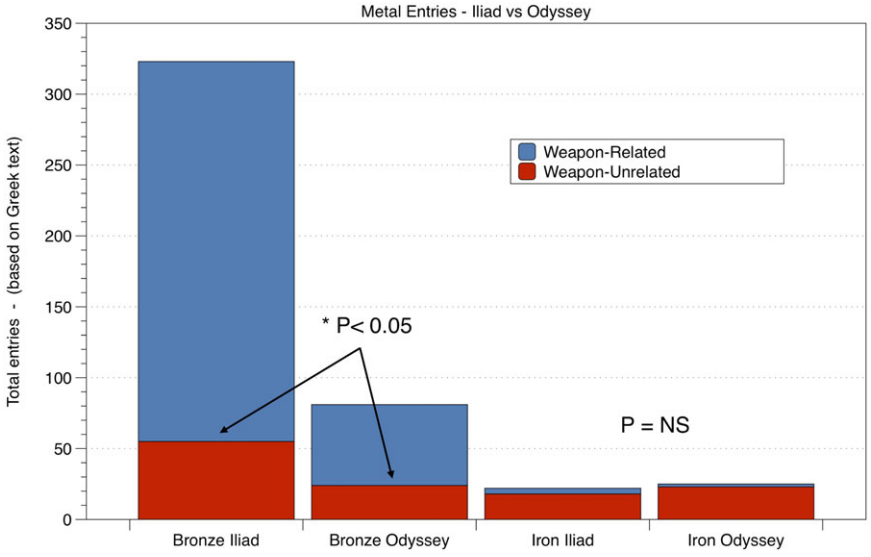


Figure 1. Weapon-related and weapon-unrelated metal entries in the Homeric poems.

and steel, respectively. Consequently, the metals copper and brass were regarded as bronze, and steel as iron, in alignment with the original Homeric Greek text.

The complete list of entries is exhaustively reported in Supplementary Tables 1–4, with each weapon-related or weapon-unrelated term, the respective native Greek word, and the citation details.

The frequencies are represented in Figure 1 (which illustrates the frequencies of bronze and iron), Table 1 (metals), and Table 2 (weapons). The weapon frequency is higher in *The Iliad* than in *The Odyssey*, as would be expected. The metal frequency is reported in both crude and amended forms (i.e. adjusted for the weapon count: Each metal entry, related to a weapon, was withdrawn from the final count to buffer the inherent discrepancies of the texts).

The amended frequencies were analysed using a two-tailed χ^2 statistic, and the significance level was set at $P = 0.05$ (i.e. a 95% probability that the null-hypothesis must be discarded) (Swinscow, 1976; Fletcher, 2009).

Statistical analysis was carried out by commercial software: PRISM 5 for MAC OSx version 5.0b – Dec. 2008, ©2009 (Graph Pad Software Inc. Boston, MA, 02110, USA).

Results

Results and statistical values are reported in Figure 1 (primary results for bronze and iron), Table 1 (metals), and Table 2 (weapons).

The key term of *The Iliad* is 'bronze'. Undoubtedly this is the most represented metal in the poem and is far more prevalent in *The Iliad* than in *The Odyssey* (Table 1; χ^2 df: 92.14, 1; $P < 0.0001$ for crude frequencies). This should not be a surprise, as *The Iliad* is a war story set in the Bronze Age. After the appropriate adjustments, a persistent significant difference ($P < 0.05$; Figure 1 and Table 1) was found in the frequency of the term 'bronze' (*Iliad* > *Odyssey*).

Significant differences ($P < 0.001$) were found for the following weapons: spear, shield, armour, arrow, greaves, and helmet. These were significantly more frequent in *The Iliad*. In contrast, the terms sword, axe-adze, and club-mace did not show statistically significant differences.

As already reported, the term 'bronze' is a major difference between *The Iliad* and *The Odyssey* (significantly more represented in the former, by two-tailed χ^2 test $P < 0.05$, even after adjustment), whereas iron, gold, and silver, displayed no significant differences between the two poems.

The global statistics were computed on the basis of 15,693 hexameters from *The Iliad* and 12,110 hexameters from *The Odyssey*. These figures correspond to the hexameter numbers in the most widely accepted versions (e.g. [Homer, 2012; Homer, 2016]). The adjusted figures (i.e. when the entries weapon-related are erased) are as follows:

'Bronze': *Iliad* versus *Odyssey*, two-tailed χ^2 test (df 5.595, 1 and $P = 0.0180^{\S}$)

'Iron': *Iliad* versus *Odyssey*, two-tailed χ^2 test (df 2.627, 1 and $P = 0.144$ not significant [NS])

Statistical significance: $^{\S}P < 0.05$; $P > 0.05$ not significant

Discussion

The present study employs the χ^2 test to evaluate the frequency of hexameters incorporating the term under scrutiny, 'bronze', in *The Iliad* compared with *The Odyssey*. As previously stated, the fundamental distinctions between the former, a poetry focused on warfare, and the latter, a poetry focused on homecoming, have been duly considered. Consequently, the necessary adjustments have been implemented to facilitate a thorough and unbiased analysis of the texts.

The results of this analysis demonstrate a statistically significant difference between these two poems, with a clear prevalence of the term 'bronze' in *The Iliad*, thereby indicating that the observed variations are not merely random occurrences but rather indicative of systematic differences.

Apart from the obvious (and significant) differences in the field of weaponry (again, war versus aftermath), there is no further disparity among the selected keywords concerning the other metals between *The Iliad* and *The Odyssey*.

The question therefore arises as to the potential interpretation of this discrepancy.

First, it should be noted that in both poems the players are fully aware and well trained in the different uses of bronze and iron for weapons and tools. Second, iron is considered a treasure (Bennet,

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Table 1. Frequency analysis – Metal entries, *Iliad* versus *Odyssey*

Metals	ILIAD (15693 Hex.)	ODYSSEY (12110 Hex.)
Bronze	323** (amended 55§)	81 (amended 24)
Iron	22 (amended 18)	25 (amended 23)
Gold	123	83
Silver	48	34

Statistical analysis performed in a contingency table analysis with a chi-squared test (Fisher's exact test was impossible to calculate owing to the large sample): §two-tailed χ^2 test $P < 0.05$; **two-tailed χ^2 test $P < 0.0001$.

Table 2. Frequency analysis – Weapon entries, *Iliad* versus *Odyssey*

Weapons	ILIAD (15693 Hex.)	ODYSSEY (12110 Hex.)
Spear	583*	85
Shield	216*	42
Armour	179*	19
Arrow	121*	49
Sword	74	53
Axe/adze	67	36
Greaves	39§	11
Helmet	35§	10
Club/mace	4	2

Statistical analysis performed in a contingency table analysis with a chi-squared test (Fisher's exact test was impossible to calculate owing to the large sample): §two-tailed χ^2 test $P < 0.05$; *two-tailed χ^2 test $P < 0.001$.

2014), similar to gold or bronze, throughout the Homeric world (Il. 6.48; Il. 9.365; Od. 14.324). Third, iron is viewed as an asset for farming and herding by Achilles himself (Il. 23.834). Furthermore, it is notable that weapons are never explicitly labelled as iron in Homeric poems, with two exceptions that will be examined below. Iron is, if anything, a synonym for axes, which are the tools targeted by Odysseus in the final stages of the poem (Od. 21.420). A thorough examination of both *The Iliad* and *The Odyssey* reveals the presence of weapons and a limited number of tools crafted from bronze, including Agamemnon's knife (Il. 19.266). Conversely, there were several tools and implements made of iron, with the conspicuous absence of iron weapons. The only exceptions to this are a highly unusual iron mace (Il. 7.141) and a solitary iron arrowhead (Il. 1.123). Hesiod, in a time close to Homer, stated that the third generation (living in the Bronze Age) had armours, implements, and houses of bronze, but no black iron (Hesiod, 8th cent. BCE); interestingly, he said nothing about the metals employed by the fourth generation, the heroes of the Trojan War (Hesiod, 8th cent. BCE). It is challenging to conceptualise a historical transitional period in which iron tools precede iron weapons of war (Whitley, 2020), yet archaeology demonstrates that the transition from bronze to iron occurred during the Late Bronze Age (LBA) IIB/III and continued during the Early Iron Age (EIA). It was not until the tenth century BCE that iron became the preferred and widely employed metal (Blackwell, 2019). These times are usually marked by the findings (mostly in graves) of bronze weapons alongside a few iron tools (Waldbaum, 1978). Furthermore, during the Bronze Age, iron artefacts were uncommon and prized items, until the Iron Age when tools and weapons were typically made of the new metal (Blackwell, 2019).

The evidence presented herein supports the hypothesis that the roots of Homeric poetry extend to the LBA, or, at the very least, incorporate material culture that is characteristic of both the LBA and EIA (Cline, 2013), potentially including memories from the seventeenth century BCE (Cline, 2013). Furthermore, the statistical evaluation conducted in the present study appears to indicate substantial differences between *The Iliad* and *The Odyssey*, i.e. a different authorship, or potentially a separate composition in different temporal periods.

The present analysis appears to be consistent with previous studies (Janko, 1982; Lane Fox, 2024), and with the current perspective (West, 2011), even if a preeminent view suggests that both poems were composed as orally dictated texts by a single author (Janko, 1998). The principle of a single authorship has recently been reaffirmed (Moran, 2022). Possibly, an Aeolian oral epic tradition was adopted by the Ionians around 800 BCE, with the redaction of *The Iliad* in the mid-eighth century BCE, and *The Odyssey* shortly after (Janko, 1982).

Both poems present equivalent traces of the relic semivowel digamma (Shewan, 1925), indicating their roots in a time at least earlier than the adoption of the alphabet (Thurston Peck, 1897).

Nevertheless, it is intriguing to observe that other elements of the poems appear to align more closely with the presumed age of Homer. Specialized literature highlights the manner in which the notion of iron readily materialises in the mind of the poet as a contemporary asset (Letoublon, 2018). Incidentally, the same paper makes reference to the introduction of the iron forging technique in Greece, which is described in detail in *The Odyssey* (Polyphemos' blinding, Od. 9.505), around the ninth century BCE (Letoublon, 2018). Furthermore, the Homeric poems appear to differentiate bloom iron from wrought and carburized iron, along with the respective techniques (Russo, 2005). This suggests that both Homer and his audience possessed the capacity to distinguish between these materials and crafts (Russo, 2005), thereby further substantiating the characterisation of the 'Homeric society' within the previously proposed historical period of the tenth to ninth centuries BCE (Whitley, 2019).

This familiarity with iron, coupled with the frequent use of the term 'bronze' and the constant relationship between bronze and weapons appears to be specific to *The Iliad*. However, even in *The Odyssey*, there is no mention of ironworking for weapons.

These observations align closely with the prevailing perspective of the LBA/EIA 'patchwork' in the Homeric poems.

The discrepancies between the Homeric poems, as noted from a philological perspective (Dedovic, 2022; Pavlopoulos and Konstantinidou, 2023), are consistent with the statistics presented here.

Despite the fact that iron comes to the poet's mind even more readily than bronze (Letoublon, 2018), *The Iliad* exhibits a significantly higher frequency of the term 'bronze' compared with *The Odyssey*.

The transition from the oral roots in the LBA to the written redaction in the EIA, or later, should not have had a significant impact on the lexicon used to define bronze and iron. These terms appear to have remained relatively stable throughout the Greek history. The term for bronze/copper followed a major path, as evidenced by the use of the term *ka-ko*, and possibly *ka-ka*, and even *ka-ka-re-a*[1] in Linear B, while in Greek it became χαλκός (*khalkós*). Linear B references are lacking for the younger iron (Melena, 2014).[1] The only exception is a one-off and somewhat

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tenuous hypothesis, *pa-ra-ku* (Witczak, 2009), which is interpreted differently by others (Palaima and Sikkenga, 1999; Tsagrakis, 2012).

The term is rendered in Greek as σίδηρος (*síderos*).

Within the framework of the EIA Aegean dialects, there were negligible variations in both terms, bronze and iron.

The evolution of both words appears to be linear, which should rule out any reasonable word mismatch during the complex evolution and subsequent redaction of the Homeric poetry.

Incidentally, iron was a relative innovation (and indeed a sort of precious metal) for the Mycenaeans, while it was well known and regarded as valuable in the cuneiform texts, at least from the fourteenth (or thirteenth) century BCE (the letters EA 22 and KBo 1.14) (Moran, 1992; Siegelova, 1984; Heltzer, 1977).

The analysis presented here is purely mathematical in nature, with no subjective elements incorporated into the process. This is evidenced by the adjustments that were performed on the full texts, with a complete removal of weapon-linked terms, thereby ensuring that no subjective criteria were applied.

The purpose of the present discussion is to explore the implications of the overrepresentation of a specific term in the two poems.

There could be a number of reasons for this discrepancy. Irrespective of the transmission chain or the provenance of the poems, the following three hypotheses can be posited: (i) the poems were dictated by different bards (assuming faithful scribes); (ii) the poems were dictated (or even written) by the same singer–poet but successively, in different periods; or (iii) the poems underwent a divergent redaction history (at different times and/or in places distant from each other). This is the centuries-old Homeric Question.

The initial hypothesis (i) was put forth in 1795 by Wolf, (1795), while the other hypotheses (i – ii) have recently been re-examined by West, who posits the additional possibility that the author of *The Odyssey* was an imitator (West, 2011). The final hypothesis (iii) appears to be in alignment with the history of the Homeric editions, from Aristarchus of Samothrace (editing *The Iliad* in the second century BCE at Alexandria), to Demetrios Chalkokondyles (editing *The Odyssey* in the fifteenth century CE at Florence) (Wolfe, 2020).

Conclusions

The present study set out to explore a peculiar, unbiased statistical difference between *The Iliad* and *The Odyssey*, by means of a straightforward frequency test.

The frequencies of the chosen keywords, namely 'bronze' and 'iron', were adjusted to avoid the inherent bias due to the warlike nature of *The Iliad*.

The statistical analysis reveals a significant prevalence of the term 'bronze' in *The Iliad* compared with *The Odyssey*.

This discrepancy may be indicative of three potential factors. Firstly, that the poems may have been dictated (or written) by different poets. Secondly, they may have been dictated by the same poet but at different times and/or in disparate places. Finally, the poems may have had a different editorial history.

However, it is important to acknowledge the inherent limitations of the present study, which include the following: Firstly, the obvious nature of the post hoc analysis; secondly, the dearth of analogous data drawn from other poetic contexts; and, thirdly, the reduced number of the terms analysed.

Notwithstanding the abovementioned limitations, the findings presented herein appear to be in accordance with previous literature (Wolf, 1795; West, 2011), as well as with the century-long editorial history of the Homeric texts.

It is evident that the three hypotheses under consideration are not mutually exclusive and may, in fact, be interdependent, thus providing a comprehensive explanation of the observed differences.

It is to be hoped that future research will be able to shed more light on the statistics of further terms and evaluate the differences, if such exist, between the poems.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S205863102510024X.

Competing interests. The author declares no competing interests.

Note

1 https://linear-b.kinezika.com/lexicon.html.

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