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Research Article

The normalization of biradical roots: the origin of triradicals and the proto-semitic language

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Many scholars have argued that Semitic triradical roots are expansions of archaic biradical roots. If this is true, then at some point in the past the entire lexicon consisted of biradical roots that then gradually changed into a primarily triradical lexicon. In this paper, I survey scholarly opinions on the biradical roots underlying triradical roots. I also describe linguistic decay formulas in Semitic studies and other methods of identifying the origin of triradical roots. Finally, I apply two linguistic normalization techniques, one binning technique and one exponential decay formula, to two data sets: Aramaic (Targum Jonathan and Onkelos) and Hebrew (Hebrew Bible). Based on the results, I argue that triradical roots emerged around 3500 BCE.

The normalization of biradical roots

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Introduction

Many scholars have argued that a biradical root underlies the Semitic triradical root.[1] Triradicalism has been heralded as the most notable feature of Semitic language. In fact, the ability to divide up lemmas into roots and patterns is considered unique to Semitic and has afforded scholars unique insights into how words and conjugations are formed. It provides a unique angle for researchers to understand how the ancient speakers developed their lexicon and all the possible morphs that they put each lexeme through. If each triradical root has a historical biradical form, then at some point the entire lexicon would have consisted of biradical roots before a gradual shift into triradical roots. In order to find the point where the shift from biradical to triradical roots begins, linguistic decay rates can be applied. In this paper, I will survey scholarly opinions on biradical roots underlying triradical roots. I will also describe linguistic decay formulas in Semitic studies and other methods of identifying the origin of triradical roots. Finally, I will apply two linguistic decay techniques, one using binning and the other using an exponential decay formula, to Aramaic (Targum Jonathan and Onkelos) and Hebrew (Hebrew Bible). Based on the results, I will argue that triradical roots emerged around 3500 BCE.

Biradicals underlying triradicals

Some scholars have argued that there are no underlying biradical roots. The most compelling arguments for the rejection of the underlying biradical root revolve around the suffixal or prefixal letters in some fashion. Jerzy Kuryłowicz makes the argument that there is no discernable value for the letters that have been suffixed.[2] So, for example, in

Biblical Hebrew the perfect suffixes primarily have *taw* in them (2ms, 2fs, 1cs, 2mp. 2fp). If the biradical expansion theory is correct, then there should be a significant number of triradical words ending with *taw* since these suffixes theoretically become attached to the roots over time.

The problem is that Proto-Semitic suffixes are unknown, both in meaning and in form. It would be easy to trace back the ancient suffixes if, for example, 80% of Semitic roots had *taw*, or any other letter, as the third radical or if every verb with a *he* in the third radical had a causal meaning. However, this is not the case This is challenging for biradical proponents because without deciphering the meaning or origin of the expansions of the biradical roots, it is difficult to decipher which letters are original and which are expansions.

A related argument, though perhaps less convincing, is that the underlying linguistic assumption held by certain of biradical proponents of "shared" letters for word classes, is inherently wrongheaded.[3] Andrzej Zabroski gives an illustration of this in English, claiming that the commonality of "bee, beetle, bug, butterfly" is accidental and no *b- "insect class" can be reconstructed. So, by analogy, Semitic class divisions are automatically suspicious because, though there might be a related class (perhaps an ancient shared suffix or prefix?), it may also be a simple coincidence (similar lexemes sharing letters does not necessitate a specific meaning or category indicator to the letters themselves).

These are the two most common and compelling arguments against biradical roots underlying the triradical roots. However, the arguments are not entirely convincing. For Zabroski's critique of word classes, an analogy with English or any other Indo-European language is inherently weak. At first glance, the example resonates with a sort of instinctual common sense. The breakdown comes when the differences between Indo-European languages and Semitic are brought into the picture. Besides the general semantic, syntactic, and even chronological distance, the triradical root is a Semitic feature not found in English. The feature of root and pattern morphology shows that ancient Semitic speakers were understanding and using language differently than Indo-European speakers. The triradical root feature is also different from English which does not have nearly as strict of a morphological patterning. The example by Zabroski has words with three, six, and nine letters that do not follow a standard CvCvC or CvC pattern at all but instead a random assortment of Cvv, CvvCCv, CvC, CvCCvCCCv. So, using a language from an entirely different language family to explain phenomena in Semitic is suspect.

In addition, the argument for letters not representing a reconstructable class and an argument for shared letters being purely coincidental are two entirely different arguments. Both might be useful against reconstruction, but both fall short of arguing against biradical roots. Whether someone can decipher or reconstruct a class of nouns based upon the initial or final letter is not an indicator that there is no class element in nouns, but instead shows a lack of evidence or understanding on the part of researchers. In the same way, an inability to categorize the ancient suffixes into specific classes that expanded the root into three radicals does not mean that those additions did not exist, nor that they must therefore be pure coincidence. This again, could be a lack of extant evidence or perhaps a process that was slow and varied enough to obscure any concrete, systematic evidence to trace. What both of those arguments do show is that stripping off the additions to find the original two radicals is extremely difficult and, in certain circumstances, it may be impossible.

On the other side of the debate, a convincing argument in the same vein as Zabroski's noun class analogy is the addition of prefixes in denominal verbs. Some lexemes go through noun and verb phases throughout their history. So as a verb becomes a noun and then back into a verb again, changes have been observed. The schematic of this movement is: 1. basic verb > 2. deverbative noun > 3. denominative verb. This is a fairly strong argument because there are concrete examples of this happening and, unlike the one posited by Zabroski, these have occurred within Semitic and specifically Aramaic. The example given is: *dahabu* 'go, pass' > *madhabu* 'religious sect' > *tamadhaba* 'adhere to a sect'.[2] This was shown by Kuryłowicz who does not dismiss biconsonantal roots completely like Zabroski or Goldenberg but examines prefixes rather than suffixes because he believes suffixal elements are more difficult to discern than prefixal elements.[4] However, the example given is a very specific process that only addresses a miniscule subset of the roots in Semitic. It is also worth noting that Kuryłowicz is cautious about identifying biradical roots and so prefers to admit a Proto-Semitic biradical root behind some triradical roots but remains uncertain whether a biradical root underlies all of them.

Taking a different tack, Edward Lipiński identifies shared suffixes.[5] Instead of a schema of chronological change, the suffixes are identified by roots sharing the first two radicals and similar meanings. The example given is from Hebrew: *prd, prm, prs, prq, prr,* all meaning “dividing” in some form. The problem here, as pointed out earlier, is that scholars are unable to define the meaning behind the endings *-d, -m, -s, -q, -r.* It has also been noted that there are words sharing two radicals that do not share a meaning or words which scholars have claimed share a meaning but in very odd ways. For example, √*lb* is proposed to be the root behind a prefixed form *ḥlb* “milk” and a suffixed form *lbn* “white” but even with the shared spelling, the claim of a shared meaning seems strained.[6] So, it is clear not all words sharing two radicals are necessarily related but many appear to be. Also, the inability to decipher what the suffixes add to the meaning does not negate the existence of those suffixes. Identifying a shared meaning between roots sharing two radicals may point to an underlying biradicalism even though the reconstruction of any single biradical lexeme might be on tenuous ground.

The two strongest, and most heuristic, proponents for the existence of complete Proto-Semitic biradicalism are Gregorio Del Olmo Lete and Bernice Varjick Hecker. Hecker argued that the earliest Semitic consisted of biradical roots that were expanded to triradical forms in the daughter languages and attempted to create a lexicon of these biradical lemmas. The conclusion of her comparative linguistic analysis between roots in Akkadian, Biblical Hebrew, Aramaic, Arabic, Ge’ez, Sabaean, Mandaic, Ugaritic, and Syriac is:

> The data show that 197 of the 272 morphemes, or 72.42%, have two or more variants in the nine languages chosen for this paper. Another 19 morphemes have remained as biradicals. Adding the biradicals that have multigenerating reflexes to the biradicals that had no reflexes but entered the daughter languages in their original form totals 216. Thus, 216 out of 272 morphemes, 79.41%, have a clear biradical origin.[7]

Gregorio Del Olmo Lete has also attempted to reconstruct a Proto-Semitic lexicon by analyzing ten morphemic determinatives across Semitic languages both ancient and modern.[8]

The ability to reconstruct Proto-Semitic or Afrasian forms is a very different endeavor from arguing that the historical evidence of a biradical history has merit. Even though identifying each underlying root or parsing out the original forms may be difficult, or in some cases impossible, many scholars appear to believe that biradicals underly the triradical forms of Semitic roots.

Another way to analyze this underlying form is to decipher when the change might have occurred. Even without tracing each individual root or deciphering the prefixes and suffixes that have been attached and their meanings, the biradical history should be evident based upon studies of linguistic change. In the next section, I will introduce studies using decay formulas to trace linguistic changes from a computational linguistics perspective.

Computational linguistics and decay formulas

One computational study of the development of triradicals was done by Agmon and Bloch in two parts.[9] The first half of the argument is that terms related to hunter/gatherer life are primarily biradical whereas farming terminology is triradical. These terms are based upon reconstructed Proto-Semitic forms which in turn are based upon lemmas shared between Akkadian and at least one additional West Semitic language. The Proto-Semitic reconstruction argument appears difficult to prove definitively as it is an analysis of words (with very few attested occurrences at that) which have been reconstructed into biradicals. These reconstructed forms are then argued to be biradicals. However, these are then set against other terms that have not been reconstructed and so are classified as triradicals. This reconstruction type of argument must contend with criticisms of the sort noted above by Zabroski to prove the distinction between coincidental relationships versus concrete lineages.

The second half of the argument, and the one being focused on here, quantitatively analyzed Biblical Hebrew verb forms. The methodology was to divide out strong from weak roots and then apply an exponential decay formula. The goal was to reverse the time that has elapsed in normalizing the roots from biradical to triradicals and thereby find a point when all the roots were biradicals. The argument is that language normalization occurs at a consistent rate (exponential decay). So, if at one point in time half of the language has “normalized” to triradical roots, at a predictable time in the past only a quarter of the language would be normalized and, even further back in history, a point in time could be identified where all the language would be biradical because the normalization process had not started. The results of their study yielded a crossover date of about 7,800 years before the writing of the Hebrew Bible so about 9000-8000 BCE.

Methodology

To test the viability of Agmon and Bloch's method, I attempted to recreate it using the Aramaic Targum. Jonathan and Onkelos were chosen as the base texts, as opposed to other Targumim, for four reasons. First, these two share the closest compositional timeframe of the Targumim that have survived. They also have the most shared linguistic features, and they should give the largest amount of text (Onkelos Torah and Jonathan Nevi'im). The additional appeal of these two texts, especially of Onkelos, is that they were highly regarded in the Rabbinic tradition, so they were copied and preserved more carefully than the Palestinian Targumim.[10]

Given the Aramaic of both Jonathan and Onkelos have roots in the first and second century but underwent revision until the fifth century, a date of around 250-500 CE is the baseline. So, 500 CE will be used as a rough date for the final form of the Aramaic texts and the origin date of triradicals will be calculated back from this.

However, when testing the data from the Targumim with the Hebrew data from Agmon and Bloch, a question of categorization arose. The weak roots defined by Agmon and Bloch are: the "hollow" II-*w/y* roots, all I-*n*, I-*w*, roots with a reduplicated last consonant, and most I-*y* and III-*w/y* roots.[11] However, these are missing a couple of weak root features that account for a significant number of Hebrew and Aramaic roots. The first is the final *he*. The consonantal aspect of this letter is frequently lost in the formation of the vowel *qamets he.* In addition, many verbal conjugations frequently drop the final *he* or assimilate it into suffixes.[12] The second weak biradical form is the quiescent *aleph*. The consonantal force of this letter is lost frequently as well, especially at the end of a syllable (where the preceding vowel tends to lengthen in response to this consonantal loss to become a long open syllable).[13]

With these two additions to the weak roots, the Hebrew and Aramaic roots were reseparated into weak and strong, and the decay function reanalyzed. The analysis was two-fold: first, the roots were analyzed through a binning technique proposed by Lieberman et al. and, second, they were analyzed through a decay formula proposed by Agmon and Bloch.[14]

Binning technique

Lieberman et al. proposed an equation of normalization building on "an evolutionary hypothesis underlying the frequency distribution of irregular verbs: uncommon irregular verbs tend to disappear more rapidly because they are less readily learned, and more rapidly forgotten" which has been proposed by many other linguists.[15] They suggest that this normalization occurs at a consistent rate, so the length of time it takes a form to normalize can be calculated based upon the frequency of the word's usage.

So, the most frequent verbs normalize more slowly than the less frequently used words. As Lieberman et al. notes, "Therefore, an irregular verb which is 100 times less frequent is regularized 10 times as fast. In other words, the half-life of irregular verbs is proportional to the square root of their frequency."[16] The rates given by Lieberman et al. are: 10[2] = 14,400 years, 10[3] = 5400 years, and 10[4] = 2000 years.[16]

For this paper, the Hebrew and Aramaic words were sorted into bins based upon frequency (occurrence of the term/all occurrences) and then plotted on a chart according to the respective bin (Figures 1 and 2). This sorting was done for all words (black), weak roots (blue), and a weak root prediction (green). The weak root predictions for normalization rates use 3500 BCE as the time when all terms were biconsonantal. So, for example, if biradical roots began to normalize into triradical roots in Aramaic around 3500 BCE, the data from the Targumim should reflect a lexicon after a normalization process of about 4000 years. If this is the case, almost all the words in the frequency bin 10[4] would be normalized into triradicals but very few terms in the 10[2] bin would be normalized.

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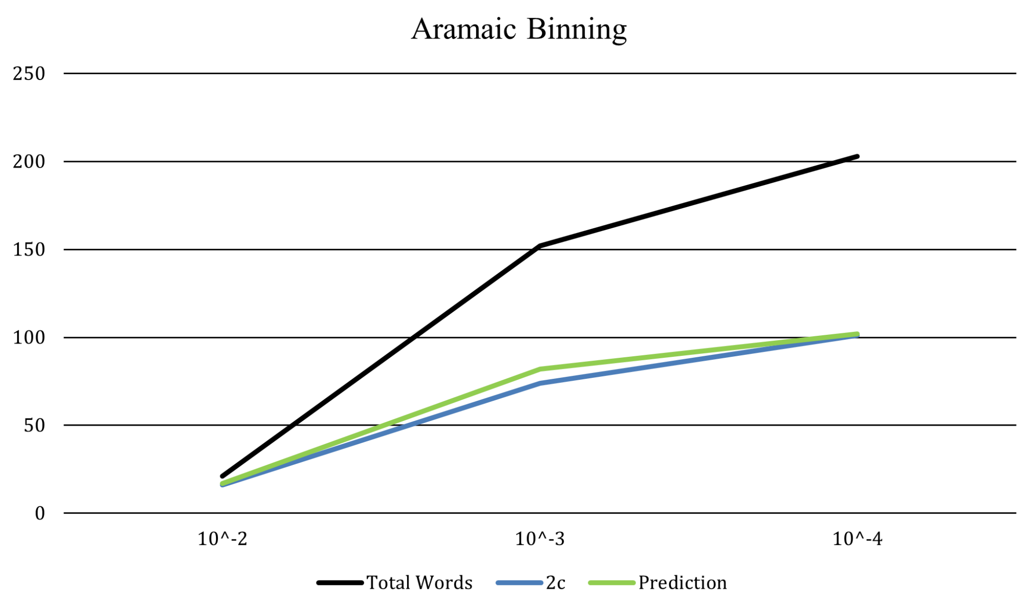

Figure 1. Aramaic Binning

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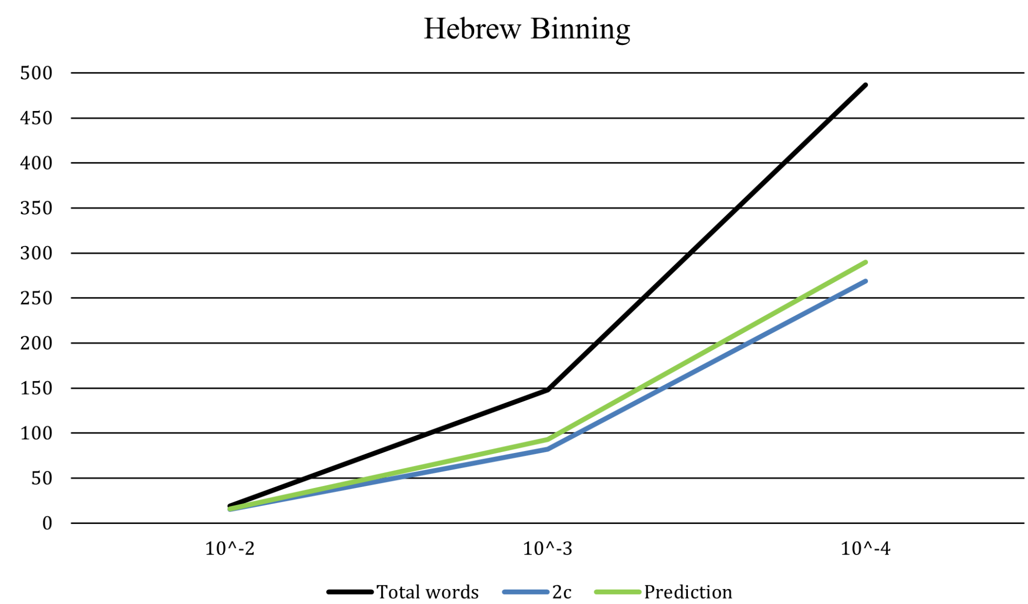

Figure 2. Hebrew Binning

The decay rates proposed by Lieberman et al. have been adjusted for this study for three reasons. First, the corpus of the Hebrew and Aramaic texts is smaller than the English corpus used by Lieberman et al. Second, the difference in normalization rates between an Indo-European language and a Semitic language are likely different. Third, additional factors have influenced development in English that are not applicable to the Hebrew Bible or Aramaic Targum: the establishment of it as a lingua franca (and contact with other languages), professional editing in modern publishing, and the regard for the texts (literature versus holy scripture).[17]

Given the geographically smaller origin of the Hebrew and Aramaic texts and the regard for them as scripture (i.e., less likely to be edited or updated), the time for replacement should be longer than the English texts. Since the two texts are from the same language family and used by the same, or similar, groups, the normalization rates should be similar between them. The normalization rates used in the charts (Figures 1 and 2) are: 10[2] = 14,400 years, 10[3] = 4500 years, and 10[4] = 4000 years.

The number of remaining weak roots is calculated using the half-life formula: N (t) = $N_0(1/2)^{t/t}$[1]/[2]. In this formula N (t) is the number of weak roots remaining while N_0 is the initial quantity, which was calculated using the total number of lemmas (assuming that all lexemes where originally biconsonantal). The time (t) was calculated to 4000 years for Aramaic and 3000 years in Hebrew with $t_{1/2}$ being calculated as the normalization rate estimated for each frequency bin.

Using 3500 BCE as the start of normalization into triradicals, the predicted number of weak roots fits the data from both the Hebrew and Aramaic lemmas using the same normalization rates for the bins in each of the data sets (see Figures 1 and 2).

Decay formula

A second formula was used to corroborate the results of the binning technique. For this, the exponential decay formula from Agmon and Bloch was used.[18] The formula for the decay of biconsonantal roots is:

$$f_{2c}\,(\mathrm{r}, \mathrm{t}) = \mathrm{A}_{2c} f_0\,(\mathrm{r})\,\exp\,[-k\,(f_0(r))\,t]$$

The formula of the increase of triconsonantal roots (through normalization) is:

$$f_{3c}\,(\mathrm{r}, \mathrm{t}) = \mathrm{A}_{3c} f_0\,(\mathrm{r})\,\exp\,[k\,(f_0(r))\,t]$$

Rank (r) and time (t) are found by adjusting the time and the constant (A_{2c} or A_{3c}) and fitting the prediction to the data input on a logarithmic scale (Figures 3 and

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4). The time (t) used for Aramaic is 4000 years ago and Hebrew is 3000 years ago. This predicts the emergence of triconsonantal roots to be around 3500 BCE.

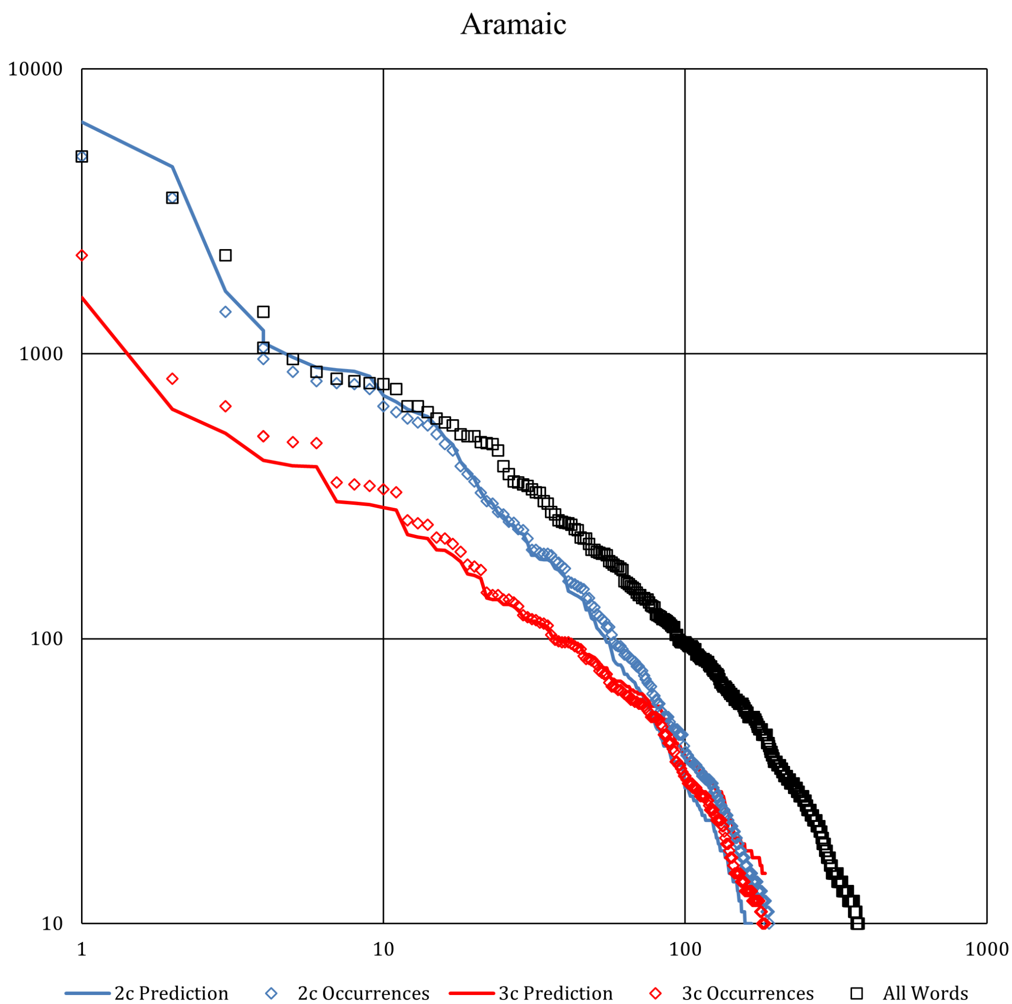

Figure 3. Aramaic

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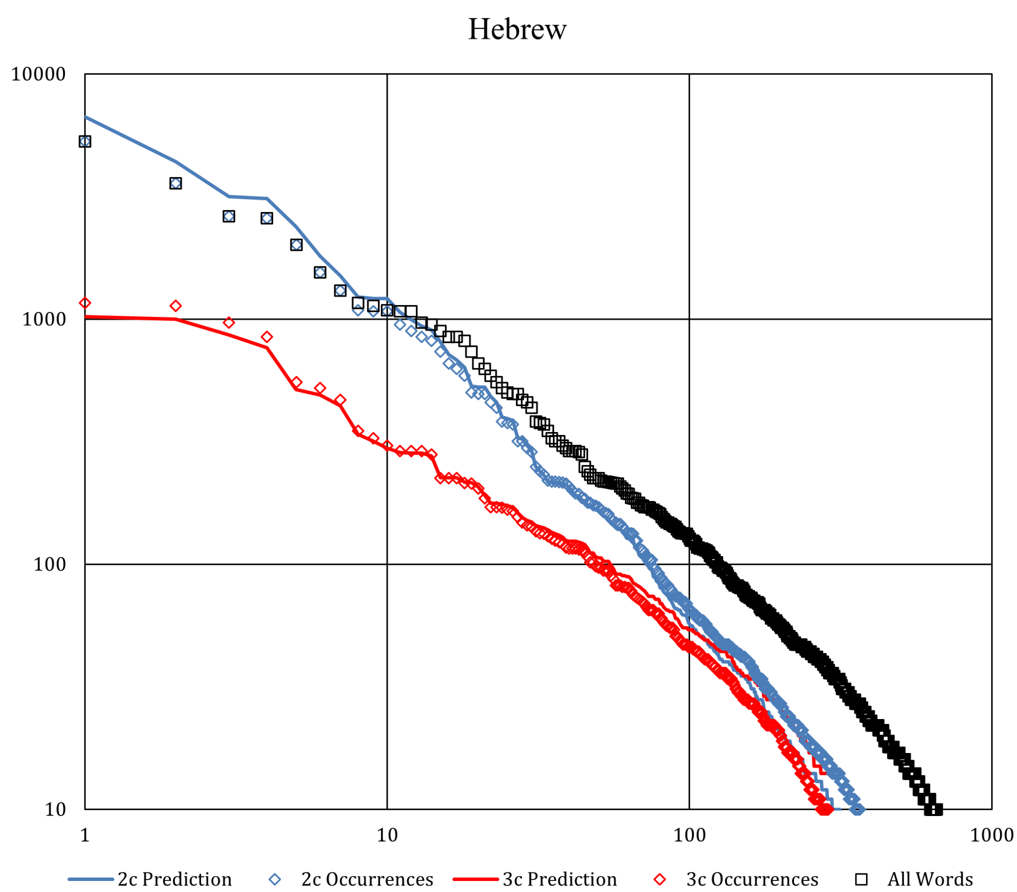

Figure 4. Hebrew

The constant (A_{2c} or A_{3c}) is derived from the exponent for natural languages in Zipf's power law, which is usually ≈ 1.[19] However, since the biconsonantal roots are being lost and were once much more prevalent, the constant should be greater than 1. Conversely, since the triconsonantal roots are increasing and were once nonexistent, the constant should be less than 1.

In fact, when the formula is run for Aramaic and Hebrew, Aramaic deviates more severely from the normal Zipf exponent. So, the prediction for Hebrew biconsonantal roots fits the data with a constant of 2 but Aramaic at 2.5. In addition, the prediction for Hebrew triconsonantal roots fits at a constant of.5 but Aramaic is at 3.5. This increased deviance from the Zipf exponent should be expected because Aramaic has had more time for the biconsonantal roots to decay and the triconsonantal roots to multiply.

The frequency of a term is indicated by f_0 (r) and the formula k (f) is a power-law rate coefficient for lexical replacement. Agmon and Bloch adopted the formula and rates of decay from a study of Indo-European language change by Pagel et al.[20] For comparability, the formula and rates used by Agmon and Bloch have been used in this study. The formula k (f) is:

$k\,(f_o) = B/(X\,f_o)^{\beta}$

In Agmon and Bloch, B =.55 thousand years and β =.13 as the rate of lexical replacement and frequency of use.[21] The in this formula is a ratio for Hebrew and Aramaic. The studies by Pagel use frequencies per million words, but the Hebrew Bible and Aramaic Targumim do not contain that many words so a ratio must be used.[22] Hebrew has about 305,500 words and so 3.27 is inserted for X. Aramaic has 356,730 words and so 2.8 is used.

Using these parameters for both Hebrew and Aramaic but adjusting the time and constant, the biconsonantal and triconsonantal predictions follow

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the language data when calculated to 3500 BCE (figures 3 and 4). This second decay formula following Agmon and Bloch confirms the results of the frequency bins that were adapted from the study proposed by Lieberman et al.[16]

Interpretation

The argument for the older date by Agmon and Bloch was based upon cultural change in the Ancient Near East from hunter/gatherer to agriculture.[23] However, the new calculation puts the date to the rise of civilization with Sumer in Mesopotamia and the transition from the Predynastic to the Early Dynastic Period in Egypt.

Even more intriguing than the rise of civilization and material culture change is the rise of Proto-Semitic happening at that time. According to Kitchen et al., Semitic languages arose from Afrasian language around 3750 BCE.[24] The technique used by Kitchen et al. was not triradical versus biradical linguistic decay rates but Bayesian statistics using a form of the Swadesh word list from twenty-five Semitic languages. The dating of the rise of triradicals to the rise of Proto-Semitic language also fits well with the model proposed by Hecker wherein a biradical Proto-Semitic form undergoes triradical permutations within the daughter languages.[7]

So, with this correlation in mind, triradicalism can be called the hallmark of Semitic language definitively. It is not only a curious aspect of the daughter languages as we have them or an abstract creation of Semiticists but a form that developed during the same time as the language family itself began to distinguish itself. It is unclear whether this feature was the driving force, or feature, behind the creation of Semitic branches out of Afrasian or just one of a number of features that developed concurrently with the rise of Proto-Semitic branches, but the concurrence of the branching of Proto-Semitic with the rise of triradicalism makes the correlation intriguing.

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