



Vocalic Shifts in Attic-Ionic Greek

BRIDGET D. SAMUELS
University of Southern California

Abstract

In this work, a number of vocalic changes in the Attic-Ionic Greek dialect group are examined from chronological and theoretical perspectives. These include a vocalic chain shift among the (originally) back vowels that occurred in both Attic and Ionic, quantitative metathesis, the second compensatory lengthening, and the Attic *Rückverwandlung* (reversion). After discussing the orthographic evidence from inscriptions found throughout the Attic-Ionic dialectal area and taking into consideration both synchronic and diachronic phonological theory, I advocate for a particular relative chronology of these changes. Finally, the significance of these changes for a theory of vocalic chain shifting is presented. This involves a consideration of the status of /u/-fronting and of push chains in historical phonology in general.

1 Introduction

The goal of the present paper is to analyze a set of changes in the Attic-Ionic Greek vowel system that hold interest for both historical linguists and phonological theorists. I hope to shed some light on some of the prehistoric and historical developments within the Attic-Ionic dialect group throughout the first millennium BCE by securing a relative—and, to the extent that it is possible, absolute—chronology of changes to the vocalic system of these dialects, focusing particularly on the Attic-Ionic vocalic chain shift and the Attic reversion (*‘Rückverwandlung’*), and by examining the phonetic motivations that led to such dramatic phonological restructuring. Finally, I discuss the import of this series of changes as it pertains to the controversy surrounding the empirical and theoretical motivations for the ‘push chain’ mechanism.

2 Historical background

The Proto-Greek vowel system had five short vowels—two high, two mid, and one low, each with a long counterpart. This system essentially

continued the Proto-Indo-European system; Greek short vowels represent PIE short vowels, while Greek long vowels represent PIE long vowels or short vowel + laryngeal sequences (Sihler 1995, 35). I schematize the Proto-Greek vowel situation, which is also attested in Mycenaean inscriptions from the second millennium BCE, in (1) below.

(1) Proto-Greek vowel system ca. 1800 BCE (Bartoněk 1966)

| | | | |
|---|---|----|----|
| i | u | i: | u: |
| e | o | e: | o: |
| a | | | |
| | | a: | |

We will be focusing on the Attic-Ionic dialect group (see figure 1 for a representation of their geographical extent). Proto-Attic-Ionic was probably spoken near Attica in the early first millennium BCE.



Figure 1: Greek dialects in the classical period (ca. 500-300BCE)

Attic can be seen as distinct from at least some varieties of Ionic by the early eighth century BCE, simply by virtue of Ionian colonization of the west coast of Asia Minor during this time period, which isolated what would become the East Ionic dialects. Three dialect groups can be

distinguished within Ionic, all of which were distinct by 500BCE: West Ionic spoken in Euboea and north of Attica, Central Ionic spoken in the Cyclades, and East Ionic spoken in Asia Minor, south of Smyrna (Buck 1965).

The loss of coda /s/ in Ancient Greek resulted in the lengthening of the preceding vowel in most dialects, as in *ἐκλινσα* /eklinsa/ ‘I leaned’ > *ἔκλινα* /ekli:na/.¹ Another source of long vowels was ‘contraction’ of vowels that came into hiatus, for example due to intervocalic loss of /h/. Some cases of contraction, such as /e/+/e/ and /o/+/u/, produced long mid vowels. However, unlike most of the other dialect groups, Attic-Ionic did not merge these results of compensatory lengthening and contractions with the inherited long mid vowels. They instead created another set of long mid vowels, higher than and distinct from the original two. These are known as the ‘spurious diphthongs,’ orthographically represented by ⟨ει⟩ and ⟨ου⟩ in the standardized Attic system. The inherited [ej] and [ow] diphthongs merged with these vowels by the fourth century BCE in Attic-Ionic.² The result was the system in (2). I follow the IPA here; in the traditional literature, the close mid long vowels are typically represented as [e:], [o:] and the open mid long vowels as [ɛ:], [ɔ:].

(2) The early Proto-Attic-Ionic vowel system, ca. 1000BCE

| | | | |
|---|----|----|----|
| i | u | i: | u: |
| e | o | e: | o: |
| a | ɛ: | ɔ: | |
| | | a: | |

The Northwest Greek dialects, Megarian, Corinthian, and East Argolic also followed the Attic-Ionic pattern, though they differed slightly in the details of exactly what comprised the ‘secondary’ mid vowel category. Pamphylian, East Aegean Doric, West Argolic, and Cretan had four height distinctions as well, but they derived this system in other fashions (Bartoněk 1966, 61). Though symmetric, from a

¹ Loss of postconsonantal /w/ also induced lengthening of the preceding vowel in Ionic, but did not cause lengthening in Attic.

² The Boeotian adoption of the Ionic alphabet (probably via Attic) provides a *terminus ante quem*: the first half of the fourth century BCE. At that time, the Boeotians adopted ⟨ου⟩ for writing monophthongal [u] (Bartoněk 1966, 80). The Boeotian borrowing will be important for dating the [u] > [y] and [o:] > [u:] shifts, and we will return to this fact shortly.

Structuralist perspective the four distinctions of height among the long vowels was an inherent source of instability for the group of dialects with this type of vowel system (Martinet 1952, 1955, Ruipérez 1956, Bartoněk 1966, Szemerényi 1987). Over the first millennium BCE, the system of Attic-Ionic underwent numerous changes, some common to the whole Attic-Ionic group and others unique to a subset of the dialects.

Even prior to the first Attic inscriptions, Proto-Greek /a:/ raised and fronted, ultimately merging with /ɛ:/ in Attic and Ionic. Many accounts explain this as the first of many changes which began to alleviate pressure in the crowded back series of the long vowel system (Ruipelez 1956, Bartoněk 1963, 1966, Szemerényi 1987). Orthographic evidence supports the view that [a:] raised to [ɛ:] through the intermediate value [æ:] — Cycladic Ionic inscriptions directly attest a three-way distinction between [a:], [æ:], and [ɛ:]. Most notably, the well-known Nikandre inscription from the island of Naxos (late 6th century BCE) has etymological /*e:/ represented by ⟨E⟩, etymological /*a:/ represented by ⟨H⟩, and new /a:/ from compensatory lengthening represented by ⟨A⟩ (inscription and analysis available in Buck 1965, 190; cf. also Gates 1976, 190). From this one can conclude that [æ:] did not merge with [ɛ:] in Cycladic until sometime after the sixth century BCE. This interpretation is accepted by, among others, Allen (1974), Buck (1965), Sihler (1995), and Smyth (1956).

Of course, the Cycladic situation does not reflect on the date of the merger in the other Attic-Ionic dialects. Any history of Attic-Ionic must also explain why [a:] fronted in the first place. The [a:] to [æ:] shift is a case of the “inception problem” (Lass 1976): it seems easy enough to explain the collapse of [æ:] and [ɛ:], but in order to get to the stage at which merger becomes possible, the [æ:] must first develop for independent, as yet unidentified reasons. Let us set this issue aside for the time being, because in many respects [a:]-fronting parallels [u:]-fronting, which we will see shortly.

Later, the loss of /n/ in -Vns- clusters resulted in lengthening of the vowels in these environments (Smyth & Messing 1956, 14). This change is commonly known as the second compensatory lengthening.³ The result of ⟨α⟩ undergoing the second compensatory lengthening yielded a new /a:/ phoneme, not /æ:/. There are two possibilities: either the second compensatory lengthening happened after the [a:] > [æ:] shift, or

³ The first compensatory lengthening, also a Proto-Attic-Ionic change, involved loss of [h] (derived from Proto-Greek *s and *j) in certain sequences. The [a:] created by the first compensatory lengthening did feed into the [a:] > [æ:] change, so it must have occurred prior to any of the other changes we are discussing.

it preceded and caused the fronting of the older /a:/ (> [æ:]), with the distinction between the two maintained by nasality on the new [ã:] after the loss of the nasal consonant following it. In either case, the second compensatory lengthening yielded uniform results in all Attic-Ionic dialects, so it must have occurred before the dialects split; this implies that the [a:] > [æ:] shift happened during the Proto-Attic-Ionic period.

After Attic had split off from Ionic, the remaining /æ:/ merged with /ɛ:/ in both Attic and Ionic independently, returning the system to its former, four-height-distinction, symmetric state. Evidence for dating the merger after the Attic-Ionic split comes from the Cycladic inscriptions mentioned above, which show a three-way distinction and therefore preclude the possibility of a Proto-Attic-Ionic merger. Other evidence comes from the ‘Attic reversion’ (Rückverwandlung) which resulted in differing treatments of /æ:/ after {e, i, r} in Attic and Ionic. This is the subject of section 3.

The next phase of vocalic changes takes us from this merger of [æ:] and [ɛ:] and into the period of back-vowel chain shifting discussed in section 4. After motivating and dating the developments that led to the [æ:] ~ [ɛ:] merger, it will be possible to trace the developments of the [originally] back long vowels, including the fronting of [u:] to [y:] and the raising of [o:] to [u:].

3 The Attic reversions

3.1 Data & motivation

Historians of the Greek dialects have long recognized that the Attic-Ionic dialect group differed from the other dialect groups in its treatment of the [a:] inherited from Proto-Indo-European. While dialects typically maintain this sound as [a:] (⟨ᾶ⟩ in Greek orthography), in Attic-Ionic the inherited [a:] merged with inherited [ɛ:], written in the standard Ionian alphabet as ⟨η⟩. In Attic, however, this development proceeded somewhat idiosyncratically. In many cases after {e, i, r}, Attic exhibits ⟨ᾶ⟩ rather than the expected ⟨η⟩. A summary of the correspondences among the dialect groups is provided in Table 1 below.

| <i>gloss</i> | Attic | Ionic | other dialects |
|--------------|-------|-------|----------------|
| ‘honor’ | τιμή | τιμή | τιμ |
| ‘country’ | χώρᾶ | χώρη | χώρᾶ |
| ‘house’ | οἰκίᾶ | οἰκίη | οἰκίᾶ |
| ‘new’ | νε | νεή | νε |

Table 1: Correspondences between Attic, Ionic, and common Greek /*a:/

As we have already seen, [a:] raised to [e:] through the intermediate value [æ:], as attested in Cycladic Ionic inscriptions with a three-way distinction between [a:], [æ:], and [e:]. These inscriptions represent etymological /*e:/ with ⟨E⟩, etymological /*a:/ with ⟨H⟩, and new /a:/ from compensatory lengthening with ⟨A⟩. Differences of opinion begin to arise when we consider the question of how the Attic system came to have the pattern of exceptions noted in Table 1. Two logical options have been explored in the literature. Some authors have opined that [a:] never raised to [æ:] in Attic after {i, e, r}, while others have proposed that the change did proceed in all contexts in Attic as well as Ionic, but that later a reversion of [æ:] to [a:] occurred in certain environments in Attic alone. Coming from a phonological perspective, we might ask ourselves how this alleged reversion occurred. The three phonemes in question, /a/, /i/, and /r/, do not *prima facie* seem to have anything in common that might trigger a lowering and/or backing effect on [æ:].

The ‘traditional’ or ‘linguistic’ view (Brandenstein 1954, Gates 1976, Lejeune 1972, and many others) holds that the development of [a:] to [æ:] was a Proto-Attic-Ionic sound change. Under this analysis, Attic once exhibited the change to its fullest degree, and only later underwent a change taking [æ:] back to [a:] in certain environments. Other scholars, most notably Schwyzler (1939), have proposed models in which the change from [a:] to [æ:] was never fully completed after /e, i, r/. Because all these changes are prehistoric in Attic-Ionic, there is no written record to help us distinguish between these two proposals. In Appendix A, I give a representative sample of the wide range of analyses that have been proposed. Here I focus on one relative chronology that I believe is plausible from a phonological perspective.

In the absence of a fortuitous archaeological find, it will remain a mystery whether the [a:] to [æ:] change proceeded to completion in Attic. Recent exemplar-based models of sound change, however, can help point to a likely scenario. I propose that the [a:] > [æ:] shift in Attic can be viewed in much the same way as /ow/-fronting in American English, as discussed by Labov (1994, 2001). For example, while /ow/ is generally fronted in many dialects of American English, this fronting seems to be blocked by an /l/ following the vowel. Phonetically, the backing and rounding seems to be an effect of the vocalization of /l/ in these dialects. A group of ‘laggards’ with exemplars clustering on the margin of a phonemic category thanks to phonetically-conditioned effects—/owl/ words, in this case—can split off from the original phoneme and stand alone as a separate category.

In a similar manner, perhaps the shift of [a:] to [æ:] did occur in all positions in Attic, but phonetic factors caused the pronunciation of the new [æ:] to remain a bit more open after some segments, namely /e, i, r/.

The lowering effect of rhotics on a following vowel is well documented (see Walsh Dickey 1997, 134 for an extensive list). Also, under an analysis of [a] as pharyngeal, following Delattre (1971), McCarthy (1994), and others, the lowering to a more [a:] -like vowel after the rhotic can be explained as the spreading of [pharyngeal]. Dell & Tangi (1993) and Walsh Dickey (1997) have posited such occurrences for other languages. The lowering effect of [i] and [e] on [æ:] can be explained as dissimilation (Szemerényi 1987), especially since independent evidence shows us that Greek used many strategies to avoid having similar vowels immediately adjacent to one another. In other cases in the language where two front vowels came into hiatus, contractions or other repair strategies occurred.

At some early stage, then, I propose that Attic had an [æ:] phonemic category with allophonic variation producing a lower version of the vowel after /r/ and {i, e} for independent reasons. Later, the second compensatory lengthening occurred: loss of /n/ in -Vns- clusters and resonants (with the exception of /r/) in -VsR- clusters resulted in lengthening of the vowels in these environments (Smyth and Messing 1956, 14). After the re-introduction of [a:], in the new Attic dialect the low /æ:/ allophone would have severed its ties to /æ:/ and fallen together with /a:/. Later still, the remaining /æ:/ merged with /ɛ:/ in both Attic and Ionic independently, relieving pressure in the crowded front sector of the long-vowel system.

Following Peters (1980), I suggest that the 'reversion' (i.e., the category switch from /æ:/ to /a:/) happened in two parts.⁴ Others (e.g. Schwyzer et al. 1939) have proposed such an analysis, but the proposal was criticized by some later scholars for being unnecessarily complicated. While it is true that a two-step reversion account lacks the "simplicity and economy, one might even add 'elegance'" of positing a single reversion (Szemerényi, 1987, 1340), from a phonetic standpoint the former seems quite reasonable given the fact that the front vowels and /r/ do not form a natural class. Dividing the reversion into two parts allows us to explain both independently, and it accounts for more forms without appeal to analogy.

Further support for separate treatments of the /r/-reversion and the {i, e}-reversion comes from elsewhere in Greek. Other dialects

⁴ The lower /æ:/ allophone could also have been created in two parts, with either the rhotic effect or dissimilation happening first. The collapse of the low post-rhotic allophone with [a:] could have happened relatively early, eliminating the low allophone of /æ:/ entirely, with dissimilation later causing the re-introduction of a low /æ:/ allophone and a second merger with /a:/. As we will see later, this chain of events seems to mesh best with Peters' relative chronology.

exhibit either rhotic-induced lowering or front vowel dissimilation, while only Attic seems to have had both. Examples of /r/'s lowering effect on neighboring vowels include occasional instances of ⟨ε⟩ substituting for expected ⟨ι⟩ after /r/ in Aeolic and a few scattered examples in Sicilian Doric and Elean (Buck 1965, 25-26); ⟨ε⟩ also lowered to ⟨α⟩ before /r/ in Northwest Greek (Buck 1965, 22).

3.2 Relative chronology

We can now begin to fit the [a:] to [æ:] and [æ:] to [e:]/[a:] changes into the chronology of Attic-Ionic phonological developments. A number of other vocalic changes in Attic, some of which also occurred in Ionic, interact with the raising of [a:] to [æ:].

One rather unusual set of Attic changes, also attested in some Ionic forms, had the combined effect of exchanging vowel length in sequences of two consecutive vowels of which ⟨η⟩ ([ε:]) was the first member. These changes collectively are known as quantitative metathesis. One change shortened [ε:] to [e] before {æ:, a:, ɔ:}, as in *πολεως* 'city (gen. sg.)' from *ποληος*. Another change affected [ε:] before {o, a}, again creating [e] as the first member but also lengthening the second member to ⟨ω⟩ (i.e., [ɔ:]) in the case of [o] or ⟨ᾶ⟩ in the case of [a] (Buck 1965, 41), as in *βασιλεᾶ* 'king (acc. sg.)' from *βασιληα*.

We must also account for one of many sets of hiatus-avoidance maneuvers in the history of Greek, namely a couple of contractions involving /eV/ sequences. The string [eæ:] contracted to [æ:], and [ea] from **eha* contracted to [æ:] as well. Finally, the loss of digamma (⟨f⟩, [w]) must fit somewhere into the picture. Though all Greek dialects lost digamma sometime after the Mycenaean period, different consequences resulted in different dialects. In Attic, loss of digamma did not produce any effects on neighboring vowels, but in East Ionic it caused compensatory lengthening. Also, digamma is attested in a few West and Central Ionic inscriptions, but not in any Attic or East Ionic ones (Buck 1965, 46). For this reason, I believe the disappearance of [w] in Attic-Ionic occurred after the group had already dissolved.

Of all the sound changes discussed above, only one—the change of [a:] to [æ:]—seems to have taken place before Attic diverged from Ionic. We can confidently place this change first in our relative chronology. To help fix the rest of the ordering, we have several Attic ⟨ᾶ⟩ and ⟨η⟩ forms at our disposal. A list of these forms appears in (3) below.

(3) Unexpected and/or informative Proto-Attic-Ionic forms

- a. /ea:/ contraction — *argurea: ‘silver’ (f.nom.sg) > Attic *ἀργυρᾶ*
- b. /ea/ (from /eha/) contraction — *orea ‘mountains’ (n.nom/acc.pl) > Attic *ὄρη*
- c. Intervocalic /w/ — *newa: ‘new’ (f.nom.sg) > Attic *νέᾱ*
- d. Half-contraction — *k^hreea ‘debts, matters’ (n.nom/acc.pl) > Attic *χρέᾱ*
- e. Intervocalic /w/ & quantitative metathesis — *para:wa: ‘cheek’ (f.nom.sg) > Attic *παρέᾱ*
- f. Intervocalic /w/, no contraction — *ennewa ‘nine’ (indecl.) > Attic *έννέα*, but cf. *astewa ‘townsman, citizen’ (f.nom.sg) > *ἄστη*
- g. Postconsonantal /w/ — *korwa: ‘maiden’ (f.nom.sg) > Attic *κόρη*

Because these changes all predate the written record in Attic, orthographic evidence will not be helpful in establishing the relative chronology. Instead, we must consider which of the forms in (3) are most likely to show phonological developments, and which could have been formed by analogy.

In item (3f) there is a direct contradiction with identical phonetic environments getting different treatments, so analogy must be at play in either *έννέα* or *ἄστη*. Since *έννέα* is an indeclinable numeral and completely isolated in the language, there is no reason why it should not have developed regularly (though cf. Gates 1976, 47, who takes *έννέα* to be “marked lexically as exempt from contraction”). On the other hand, the noun *ἄστη* (by hypothesis from **ἄστεα*) could have been formed analogically on the basis of other nouns from the same declension class. Given this assumption, it is possible to conclude that the [ea] > [æ:] contraction occurred prior to digamma loss.

Separating the /r/-reversion and the {i, e}-reversion allows for the possibility that [ea]-contraction occurred between the two reversions. We can then avoid an uncomfortable conclusion reached by Thumb & Scherer (1959) and Cauer (1909), that “the contraction product of εα, normally η, is diverted to ᾱ by a preceding e, i, or r, except where analogy is stronger (*ὄρη, τριήρη, ἐγρηγόρη*),” to quote Szemerényi’s (1987, 1341) summary. This explanation is unconstrained and not explanatory: there is no reason why analogy should be ‘stronger’ for *ὄρη* than for *χρέᾱ*, given that both of those forms once ended with *-*eha*.

The proposal I therefore adopt is a modification of the ‘traditional’ view, roughly following Peters (1980). In (4) I summarize the relative chronology of this account. It has the dual advantages of being phonetically plausible while still generating all the attested forms directly, with the exception of the *ἄστη* group discussed earlier. In

Appendix B, I provide full derivations of the forms in (3) using this chronology.

(4) Peters' (1980, 297ff) proposal (slightly emended):

- | | |
|-------------------------------|---------------------------------|
| a. Unconditioned shift | [a:] > [æ:] (Proto-Attic-Ionic) |
| b. Contraction | [eæ:] > [æ:] |
| c. Dissimilation | [æ:]...[æ:] > [ɛ:]...[æ:] |
| d. Reversion: rhotic lowering | [æ:] > [a:] / r__ |
| e. Contraction | [ea] > [æ:] |
| f. Loss of digamma | [w] > ∅ |
| g. Quantitative metathesis | [ɛ:] > [e] / __ {æ:, a:, ɔ :} |
| h. Reversion: dissimilation | [æ:] > [a:] / {i, e}__ |
| i. Merger | [æ:] > [ɛ:] |

Not all of these changes are rigidly ordered. For instance, (4b) and (4c) do not have overlapping domains of application and could easily switch places. Also, digamma loss could have happened in two separate phases, intervocalically at one time and post-consonantly at another time. This is not crucial to the analysis, as long as post-consonantal [w] remains through (4d) to correctly generate *κόρη* from *korwa.

In addition to the changes mentioned at the beginning of this section, the Peters analysis posits a dissimilation (4c) to account for *παρέᾱ* (<*para:wa:). As originally formulated by Peters, the rule would have targeted only [æ:wæ:] sequences, but there is some evidence to support a more general dissimilation of two [æ:] vowels in the same word. Szemerényi (1987, 1352), building on an observation by Tucker (1962), notes that *κρήνη* 'well, spring, fountain' (< *kra:na: cf. Doric *κράνα*) can be explained this way, as can a few other unexpected forms in Bacchylides.⁵ I therefore expand (4d) to encompass this range of cases. Finally, we must also modify Peters' formalization of the quantitative metathesis process to account for the fact that [æ:] triggered this process as well as [ɔ:] and [a:]. Notably, positing a round of quantitative metathesis this late means that this was almost certainly its second application. The set of changes are unusual enough that this is admittedly an undesirable outcome, unless we assume that enough alternations remained in the synchronic grammar to keep the rules active throughout the time period in question.

⁵ Forms such as *κρήνη* and *εἰρήνη* 'peace', with historical *[a:]...[a:] sequences, also show that [a:] developed to [æ:] in all environments in Attic, only later undergoing reversion. If this sequence of events had not happened, the dissimilation rule would not have been able to apply to these forms, and they would have yielded the unattested **κράνη*, **εἰράνη*.

3.3 Absolute chronology

While, as always, a relative chronology is easier to give than an absolute one, we can date a number of the changes to the front vowels with some degree of certainty. The Nikandre inscription, which maintained the distinctions between [a], [æ], and [ɛ:], provides incontrovertible evidence that [æ:] remained separate from [ɛ:] until the sixth century, at least in Naxos. For Amorgos and Keos, the same argument holds; there the three vowels remained distinct even into the fifth century BCE (Buck, 1965). These facts about the insular dialects say nothing about the situation elsewhere in Attic-Ionic territory, however.

Bartoněk (1963, 1966), Allen (1974) and Ruipérez (1956) insist that the [æ:] ~ [ɛ:] merger transpired by 700BCE, except in the dialects just mentioned, for which they assume that the merger had not yet occurred at the time of the /u:/-fronting we will discuss in the next section. Szemerényi (1987, 1346), in direct opposition to the other scholars, retorts that “this is quite impossible, and merely postulated on account of the ‘system’.” He further notes that long α-stem and η-stem nouns remained distinct until the end of the fifth century BCE, and that choral lyric and choruses of tragedies perfectly repair instances of [æ:] by lowering them to [a:], without any confusion regarding what belonged to the [æ:] class and what had original long /e/. Therefore, Szemerényi follows the conclusion reached earlier by Sturtevant (1920) and Tucker (1962), namely that the merger took place in Central and West Ionic as well as Attic at various times throughout the fifth century BCE, while only in East Ionic did it happen earlier, possibly as early as 700.

Early inscriptions from Attica and Ionian territory settle this debate. In even the most archaic texts from everywhere but the Cyclades, we see cases of ⟨E⟩ representing etymological /a:/. Specifically, instances of ⟨E⟩ corresponding to what we know to be older /a:/ appear in personal names in Attic graffiti from the late seventh century BCE, and in Euboean inscriptions from c.550 BCE (Jeffery 1961). If there were still a distinct, phonemic [æ:] in the non-Cycladic dialects, one would not expect them to tolerate such orthographic conflation of [æ:] and [ɛ:]. Moreover, in the choruses that Szemerényi mentions, incorrect ‘repair’ of [æ:] > [a:] sometimes occurred, which suggests that the writers no longer maintained this class themselves (Björck 1950). All this evidence indicates that the merger of Proto-Greek /a:/ (i.e., Attic-Ionic [æ:]) and /ɛ:/ occurred prehistorically in all these dialects.

4 The Attic-Ionic vocalic chain shift

We now turn to a discussion of changes to the Attic-Ionic back vowels during the first millennium BCE. This chain shift has been cited as an example of a ‘push chain,’ that is, a relatively rare type of chain initiated by one phoneme encroaching upon another. Some linguists find push chains to be theoretically expected but defer to empirical evidence (Campbell & Ringen 1981), whereas others categorically deny their existence on theoretical grounds (King 1967 et seq.), and still others have no problem with the theoretical underpinnings of the concept but lament the lack of attested examples (Hock 1986, Trask 1996). In the discussion to follow, I will evaluate the purported Greek case with an eye towards determining whether it should actually be categorized as a push chain.

4.1 Evidence & chronology

4.1.1 $v > [y]$

In 403BCE, the Athenians officially began using the Ionic alphabet, and other groups soon followed suit, abandoning their dialectal variants of the script in favor of the standard version. The Ionic alphabet was primarily characterized by the use of ⟨η⟩, indicating a long [ɛ:] sound instead of its former phonetic value of [h] (though Ionic shared this feature with some other scripts), and ⟨ω⟩, innovated for symmetry, indicating a long [ɔ:] (Buck 1965, 19). Among the groups to begin using the Ionic alphabet in the early fourth century BCE were the Boeotians. When the Boeotians adopted the Ionic system, probably through an Attic intermediary, they used the spelling ⟨ου⟩ for their [u] sound. This indicates that the phonetic value of ⟨ου⟩ in Attic-Ionic by the early fourth century was more similar to [u] than the value of ⟨υ⟩ was (Bartoněk 1966, 111). Attic-Ionic /u/ must have fronted to [y] by this time.⁶

Another piece of orthographic evidence that originally led to the suspicion of /u:/-fronting in Attic should be interpreted cautiously. The letter ⟨Ϟ⟩, known as koppa or qoppa, was a letter with the phonetic value [k] that appeared in early Greek inscriptions instead of kappa when preceding the sounds /a/, /o/, or /u/. The sequence ⟨Ϟυ⟩ is

⁶ The question of whether /u/-fronting occurred in Euboean (either it did not, or a reversion took place) remains open (cf. Bartoněk 1966, del Barrio Vega 1990, and Méndez Dosuna 1993). Whatever the case, Euboean did not participate in any of the other chain shift steps.

poorly attested in Attic-Ionic,⁷ whereas ⟨ϕο⟩ spellings were once relatively common. This led some to believe that /u/ had fronted in these dialects by the time of the earliest inscriptions. Furthermore, there is an Athenian amphora from circa 570BCE with ⟨Κρυλωιος⟩ written on it, as if the scribe could not decide whether kappa or qoppa would be more appropriate before upsilon (Threatte 1980, 22-23). This, too, has been taken as evidence for fronting of /u/ around that date. The value of this data becomes less clear when one realizes that the first attestation of ⟨κν⟩ is from about 550BCE, by which time ⟨κο⟩ was gaining ground against ⟨ϕο⟩ and there was a “prevailing tendency to liquidate completely the sign ϕ” in favor of simply using kappa across the board (Bartoněk 1963, 32). Thus, fronting might not have taken place this early. On the other hand, Bartoněk (1963, 33) notes that even a fronted [y] was “no doubt sufficiently rounded to admit phonetically of its eventual graphic combination with the foregoing ϕ.” Méndez Dosuna (1993) goes even further, saying the distribution of kappa and qoppa must be considered completely arbitrary, a mere vestige of the Phoenician system from which it was borrowed. This may be too pessimistic, though the data pertaining to qoppa is surely not definitive.

With the help of other orthographic evidence, we can ascertain the date of /u:/-fronting with greater precision. When the conventional spelling of the diphthongs was established around 700BCE, /u/ must still have been a back vowel, or ⟨EY⟩ and ⟨OY⟩ would have failed to make sense as spellings for [ew] and [ow], for which all indications point to a back offglide (Bartoněk 1966, 114). By the sixth century BCE, some Ionic texts show ⟨EO⟩ and ⟨AO⟩ rather than the conventional spellings for the diphthongs (Bartoněk 1966, 113). This evidence is somewhat ambiguous, but it may suggest that /u:/-fronting had taken place by that time, leading to confusion about the identity of the diphthongs’ offglide. One also finds confusions of /u:/ and /i:/ by the sixth century, which can only be explained by /u:/ being realized as a front vowel at that date (Teodorsson 1974, 289). Allen (1974) makes clear, however, that this does not necessarily mean that the pronunciations of <υ> and <ι> had already merged, as they eventually did, producing modern Greek [i]. We can deduce from the combination of all this evidence that the fronting of [u:] to [y:] occurred between 700 and 600BCE.

⁷ Bartoněk (1963, 1966) in fact claims that this sequence is never attested in Attic, but Threatte (1980) provides evidence to the contrary, including two cases of <ϕυ> in graffiti dated to 600-575BCE.

4.1.2 *ou* > [u:]

The question of whether this set of changes constitutes a push chain crucially depends on whether /u:/-fronting occurred before or after /o:/-raising, that is, the change in pronunciation of ⟨ou⟩ from [o:] to [u:]. If [o:] raised at least partway to [u:] prior to or concurrently with /u:/-fronting, that would be evidence for a push chain in the strictest sense: an encroachment (the raising of /o:/) causing displacement of another phoneme (original /u:/). I suggest, however, that there is reason to believe that /u:/-fronting preceded /o:/-raising by several generations, and therefore this step was a pull, not a push.

From the fourth century BCE onward, no confusions of ⟨ω⟩ and ⟨ou⟩ exist in Attic texts (Teodorsson 1974, 213). Examples of ⟨o⟩ substituted for ⟨ou⟩ also become rare after about 360BCE in Ionic (Lasso de la Vega 1956, 280) and 325BCE in Attic (Threatte 1980, 258), setting aside cases in which ⟨o⟩ was most likely an abbreviation for the genitive ending ⟨ou⟩, which is a well-documented practice. This suggests that the vowels were increasingly differentiated by the raising of the formerly close mid long vowel around this time. There is also a parallel change in the front vowels that would fit nicely in this chronology: a change which most likely originated in Boeotian, /e:/ raising to and merging with [i:], occurred sometime in the third or fourth century BCE in Attic and also happened during the latter part of that time frame in Ionic (Bubeník 1983). The raising of the two close mid vowels would then have operated almost concurrently, a situation leading to mutual reinforcement.

It appears that the Attic-Ionic raising of /o:/, then, transpired during the fourth century BCE. However unlikely it seems that “the opportunity would long have been resisted of increasing the acoustic distance” between the two mid back long vowels after /u:/ fronted (Allen 1974, 77-78), the two changes may have been separated by centuries. For this reason, I agree with Szemerényi (1987, 1349) that “it seems safest ... not to force the notion of a push-chain on these changes. We should rather view the (later) change *o* > *ū* as being the exploitation of an existing possibility.”

If this series of changes can be viewed as a push chain at all, the ‘push’ would have to be overcrowding, not encroachment. Virtually all analyses accept the relative chronology I have given with /u:/-fronting preceding /o:/-raising, even if they do not agree with the absolute dates I propose. The only work I am aware of that considers a chronology in which raising pre-dated fronting is that of Bubeník (1983).

4.2 Analysis

Since the Attic-Ionic shift appears to have started with /u/-fronting, as did two of the other three ‘push chains’ in the literature (São Miguel Portuguese and Old Scandinavian; see Samuels 2006), it is critical to explain that step in order to claim understanding of the changes that took place in these dialects. The difficulty in explaining /u/-fronting lies in the fact that, in both cases, there were other dialects of the same language that had the same four-height-distinction vowel system, yet did not undergo the same changes. Szemerényi (1987, 1348) comments on this problem:

Although the development we are discussing has been stated almost in terms of a natural law in the case of vowel-systems with four degrees of aperture in the back row, there have also been many dissentient voices. Thus, e.g., in Gallo-Romance Lat. *ū* developed into *ü*, while in Tuscan we find no such change. Similarly, there were a number of Greek vowel-systems with four degrees of aperture—but only in Ionic-Attic did *ū* develop into *ü*.

For this reason, some call upon extra-linguistic factors to explain /u:/-fronting in both Greek and Portuguese. Of Attic-Ionic, Bartoněk (1963, 38-39) says that /u:/-fronting “required the coincidence of two factors, first of the substratum impulse from Asia Minor, and secondly a favourable systemic condition implying the overloading of the back long-vowel axis,” and that “this coincidence appears to have asserted itself at the time when the substratum influence of Asia Minor was still strong enough only in the Attic-Ionic dialects”. In the same vein, early observers of insular Portuguese attributed the fronting of /u/ to ‘Keltic’ substrate influence—as scholars trying to explain French /u/-fronting have also done (cf. Ahn 2004, Haudricourt & Juilland 1949, Malmberg 1964)—because of circumstantial evidence pointing to a small Breton community on São Miguel. Rogers (1940) dismisses this idea, saying such a small group was extremely unlikely to prove so influential. This historical scenario, in short, seems implausible. As Malmberg (1964, 19) argues, “the substratum explanation has been seized on far too frequently as a convenient solution and often on very slender grounds.” One should at least try to find other factors. In this case, these are very possible to find.

Calabrese (2005) reiterates a point most explicitly stated in Optimality Theory but which is an implicit undercurrent in the earlier literature describing these particular shifts: the fronting of [u] to [y] is an instance of ‘emergence of the marked.’ All else being equal, linguistic change typically eliminates markedness rather than creating it. There must be some overriding factor causing these chain shifts, something

powerful enough to overcome the disparity in markedness between [u] and [y].

The fact that necessary *and* sufficient causes for /u/-fronting are not isolable means that, whatever our theory of why this change occurs, it will not have perfect predictive value. Like researchers studying a disease with both genetic and environmental components, the best we can do is identify “risk factors” that predispose a language towards developing in this particular fashion. At this point, we can begin to identify some of these risk factors.

Clearly, having four distinctions of height among the back vowels predisposes a language towards /u/-fronting. Labov states that “the full chain shift we call Pattern 3⁸ ... takes place only when there are four degrees of height in back. The two examples of vowel shifts in Martinet (1955) and the further cases explored by Haudricourt & Juilland [French, São Miguel, Greek, and Scandinavian] are confined to this pattern” (Labov et al. 1972, 105). Twenty-five years after that original statement, Labov himself came up with a counterexample: the American West, which exhibits both a three-height distinction in the back of the mouth owing to the merger of the vowels in *caught* and *cot*. Despite this, like virtually all other American English dialects, this dialect fronts /u/ (Labov et al. 1997). Also, the seven-vowel system with three height distinctions among the front vowels (i, e, ε) and four among the back vowels (u, o, ɔ, a) happens to be one of the two most common seven-vowel systems across languages (Crothers 1978). This seemingly rules out any proposal that argues for the inevitability of /u/-fronting simply based on the fact of a four-height distinction of back vowels, though of course frequency is not a guarantee of stability.

Another factor that has been discussed is the lack of high central vowels in /u/-fronting languages. For Attic, Teodorsson (1974, 291) posited a “latent attraction” of /u:/ to /i:/ owing to the lack of any central vowel between them. Since the Attic situation was not resolved by /u:/ merely centralizing, and because there is no reason to believe that languages prefer having a high central vowel to having a high back vowel, one can conclude that any “attraction” would be concerned with more than just filling the gap between the high vowels. At this juncture one could invoke the Pierrehumbert (2001) and Blevins (2004) approach, in which vowels move towards empty spaces to minimize perceptual confusion. However, this principle alone certainly cannot explain why /u/ would move all the way to the front. It also fails to explain why /u/-fronting would occur in languages which have

⁸ A ‘Pattern 3’ shift (Labov et al. 1972; Labov 1994, 129), such as the Attic-Ionic one treated here, consists of /u/-fronting and raising of the other back vowels.

competing central vowels. One could make the argument that the perceptual distance between the high central and high back vowel before fronting is still greater in these cases than the distance between the high back vowel and any other neighbor; this ought to be experimentally verifiable.

Calabrese (2000, 2005) instead proposes that the force overcoming the markedness of [y] is in fact another markedness constraint. He builds on the work of Lindau (1975) and Archangeli & Pulleyblank (1994) to establish an account of why [u] and [o] are articulatorily complex in a way that [y] and [ø] are not: the vowels [u] and [o] are both pronounced with the tongue root in an advanced position. As Lindau first noticed, advancing the tongue root pushes the body of the tongue up and forward, which means that “in pronouncing [+ATR] back vowels, speakers need to suppress the natural tendency to front them” (Calabrese 2005, 49). Thus, the changes of [u] > [y] and [o] > [ø] simplify articulation by preserving the [+ATR] feature at the cost of losing the [+back] feature. In Calabrese’s framework, this is manifested by a constraint disallowing [+ATR, +back] vowels with an associated repair deleting [+back] when [+ATR] is also present. One certainly need not subscribe fully to this particular theory in order to make the best of the observation. It would suffice to say that the articulatory complexity of [u] and [o] make them susceptible to fronting.

Two other details about ATR are worth mentioning. Firstly, the low [+ATR] vowel transcribed as /A/ in Somali is realized as [æ] in a process that also produces [y] from underlying /u/ and [ø] from underlying /o/ (Calabrese 2005, 50). This is a synchronic process of phonetic realization, but it is certainly tempting to draw a parallel between the Somali case and the Greek diachronic processes of [a:] becoming [æ:] and [u:] fronting as well. One could then view /a/-fronting and /u/-fronting as (partially) stemming from the same cause. Secondly, Calabrese (2000, 2005) reports that, in the Altamura dialect of Italian, [+ATR] rounded vowels front only when they appear in stressed syllables. This is reminiscent of São Miguel Portuguese Pattern 3 shift, in which fronting of /u/ primarily occurs under stress. This does not necessarily imply a connection between stress and ATR in particular, but it provides another instance of stress interacting with vocalic fronting.

4.3 Theoretical concerns

Pattern 3 shifts such as the Attic-Ionic one are very common. In addition to the examples we have already mentioned from São Miguel Portuguese, Old Scandinavian, and French (Haudricourt & Juillard,

1949), we also find similar shifts in Armenian (Vaux 1992), Somali (Antell et al. 1973), Swiss French, Yiddish, Lithuanian, Albanian, West Syriac, Akha (Lolo-Burmese) (Labov et al. 1972), “almost all dialects of American English” (Labov et al. 1997) and Norwich (U.K.) English (Labov 1994), as well as Scots, South African, New Zealand, and southern British dialects (Lass 1988). Dressler (1974) identifies numerous other instances of context-free /u/-fronting,⁹ both with and without associated /o/-fronting. Among the languages he mentions are Oscan, Umbrian, Gallo-Romance, some Iranian languages including Parachi, Brythonic, Mingrelian (Caucasian), Holoholo (Bantu), Albanian, and Frisian. Hock (1986) supplies the additional example of Slavic [u:] centralizing and losing its rounding.

The high frequency of /u/-fronting of all these types supports the intuition that “there is certainly no general requirement that any **particular** high vowel slots in a system be filled The most that can reasonably be said is that maybe at least one high vowel slot per system ought to be filled, and back isn’t necessarily the one” (Lass 1988, 399). In contrast to the abundance of [u] > [y] (> [i]) changes, examples of [y] > [u] are vanishingly rare, and Dressler (1974, 96) finds identifiable “influence of a neighboring language or a substratum or superstratum” in each case. Labov seems correct to attribute special significance to /u/-fronting and /o/-raising.

One serious question remains: what does one make of these changes? Should phonologists call them push chains, pull chains, mixed chains, or something else entirely? There is hardly consensus on this issue. The chain shift of [u] > [y], [o] > [u]—in that order—receives different interpretations by different authors. Bynon (1977), Bubeník (1983), and Ahn (2004) say that this sequence constitutes a pull chain initiated by /u/-fronting, while Hock (1986, 157) invokes both pull and push mechanisms, saying that “the overcrowding which gives rise to *u*-fronting and to the ensuing drag-chain developments commonly results from the ‘push’ of a new segment into the back vowel system.” Though Eliasson (1992) disagrees with such an analysis for Scandinavian, he implicitly agrees with Hock’s categorization for a hypothetical case. Both these positions seemingly contradict Martinet’s (1952, 133) intent; he states that “the suggested distinction between drag and push would often be blurred” in practice because “we have to deal with pressure everywhere” in cases like the São Miguel shift.

Taking Martinet’s warning seriously, rather than forcing these shifts into push, pull, or mixed categories, which are radical oversimplifications in /u/-fronting cases, I suggest using Labov’s

⁹ This includes changes of [u] (> [y]) > [i].

terminology instead. ‘Pattern 3’ is a useful designation for the shifts discussed here because it provides descriptive information about the nature and direction of the chains from a holistic perspective, whereas ‘push,’ ‘pull,’ and ‘mixed’ only indicate the possible causation of individual steps. As a corollary of being causation-based, the traditional method of classification introduces subjectivity. Simply designating /u/-fronting shifts as ‘Pattern 3’ has the benefit of neutrality with respect to this issue.

One reason why the issue of push chains has been so controversial may stem from an inconsistency in Martinet’s (1952) paper introducing the push/pull dichotomy. Martinet (1952, 132) first gives an abstract example of a push chain that clearly involves direct encroachment: “a phoneme A drifting in the direction of a phoneme C... C, instead of awaiting the impending merger, recedes before the invader.” When he presents a concrete example, though, he cites the São Miguel case, which does not involve encroachment but instead, “pressure exerted upon /u/ by the other three back phonemes of a series where margins of security are, by nature, narrower than in the corresponding front series” (1952, 133). No one contests Pattern 3 cases like the São Miguel example; the controversy centers around the hypothetical example. Those who take the abstract definition literally seem to think that Martinet thought all push chains involved encroachment, in spite of the example a few paragraphs later. This leads to the mistaken impression that “in order to be a chain shift, on the push reading there has to be a (near) collision. Push chains require that phonemes bump like balloons, billiard-balls in a rack, on a model resembling the Brownian motion of particles” (Stockwell and Minkova 1997, 286), or that “push chains would give a relative chronology with considerable overlapping between the steps” (Anttila 1989, 112). Looking at the spirit rather than the letter of Martinet’s introduction to push chains, we see that what he considered push chains are quite common indeed, but that push chains in the strict sense employed by other linguists may not be so common, or even attested at all.

5 Conclusion

This case study in Attic-Ionic shows how, when we are concerned with problems in historical phonology, helpful evidence can come from anywhere. Comparisons within the language as well as outside of it, orthographic evidence, phonetics, and structural phonology all played crucial roles in shaping our analysis of the Greek vowel system’s developments. Understanding of analogical change also proved useful by guiding us away from theories that could describe but not

adequately explain unusual forms, and by helping us determine which words' histories to believe when the developments of regular sound change could not have yielded two sets of conflicting forms stemming from the exact same phonological environment. None of these strategies alone can provide an answer, but the more they are synthesized into a holistic view of the language, the more we find that all the scattered evidence converges on a single, believable analysis.

If the discussion of the Attic reversions in section 3 had the effect of showing that phonetics and phonological theory can inform our understanding of diachronic changes, then the analysis of the chain shift in section 4 demonstrated the converse. Only by examining empirical evidence can we understand the mechanism behind chain shifting and therefore begin to tease apart the many theories that have been developed to account for the phenomenon.

Comments invited

PiHP relies on post-publication review of the papers that it publishes. If you have any comments on this piece, please add them to its comments site. You are encouraged to consult this site after reading the paper, as there may be comments from other readers there, and replies from the author. This paper's site is here:

<https://doi.org/10.2218/pihph.2.2017.1908>

Acknowledgements

I would like to thank Jeremy Rau, Jay Jasanoff, Donca Steriade, Sasha Nikolaev, Pavel Iosad and Patrick Honeybone for their helpful comments and suggestions on earlier versions of this work.

Author contact details

Bridget Samuels
University of Southern California
2250 Alcazar St.
Los Angeles, CA 90033
USA

bdsamuel@usc.edu

Appendix A

This appendix contains several proposed relative chronologies of the Attic reversions.¹⁰

(i) A ‘Traditional / linguistic’ view, adapted from Szemerényi (1987, 1339).

1. [a:] > [æ:]
2. [ea:] > [æ:]
3. [ræ:] > [ra:]
4. [w] > ∅; [ea] > [æ:]
5. [æ:] > [a:] / {i, e}_
6. [æ:] > [ɛ:]

Explicitly by analogy: all forms with intervocalic digamma showing reversion (e.g. *νέᾱ*).

(ii) A ‘Modified traditional’ view — Schwyzer (1939) [Szemerényi (1987, 1340)].

1. [a:] > [æ:] except after {e, i, r}
2. [w] > ∅; [ea] > [æ:]
3. [æ:] > [a:] / {e, i}
4. [æ:] > [ɛ:]

(iii) A ‘Thorough-going reversion’ — Thumb & Scherer (1959) [Szemerényi (1987, 1341)].

1. [a:] > [æ:]
2. [w] > ∅ / V_V
3. [æ:] > [a:] / {e, i, r}
4. [w] > ∅ / C_
5. [æ:] > [ɛ:]

No position regarding [ea] contraction. If it occurred after (2), /rea/ cases would have to be by analogy.

¹⁰ Where I note a page number from Szemerényi (1987), the changes shown in this appendix are adapted from the summaries of the various treatments presented there. In several cases I have added obviously implied steps, such as [æ:] > [ɛ:]. I have also changed the symbols used for the mid vowels to conform to the IPA.

(iv) A 'Moderate reversion' — Thumb & Scherer (1959) [Szemerényi (1987, 1341)].

1. [a:] > [æ:] except after {e, i, r}
2. [w] > ∅ / V_V
3. [æ:] > [a:] / {i, e}_
4. [w] > ∅ / C_
5. [ea] > [a:] / {e, i, r}_
6. [ea] > [ɛ:]
7. [æ:] > [ɛ:]

Explicitly by analogy: all forms with [rea] ultimately contracted to [ɛ:] (e.g., *ῥρη*).

(v) Szemerényi (1987)

1. [a:] > [æ:]
2. [w] > ∅ / V_V; [æ:æ:] > [eæ:]
3. [æ:] > [a:] / {e, i, r}_
4. [w] > ∅ / C_
5. [ea] > [a:] / {e, i}_
6. [ea] > [æ:]
7. [æ:] > [ɛ:]

(vi) 'Hypothesis A' — Gates (1976)

1. [a:] > [æ:]
2. [æ:] > [a:] / r_
3. [w] > ∅
4. [æ:] > [a:] / {i, e}_
5. [æ:] > [ɛ:]

'Hypothesis B' — Gates (1976)

1. [a:] > [æ:]
2. [w] > ∅ / V_V
3. [æ:] > [a:] / {e, i, r}
4. [w] > ∅ / r_ [NB: unknown why only [r] was included—BDS]
5. [æ:] > [ɛ:]

In both hypotheses, explicitly by analogy: *-ewes proper names; "[analogical] pressures ... operated freely after *r*, but were interfered with by a variety of special circumstances after *e* and *i*." Also in both hypotheses, [ea] and [eo] contracted prior to intervocalic digamma loss, and quantitative metathesis took place before [r]-reversion.

(vii) Sihler (1995)

1. [a:] > [æ:]
2. [w] > ø / V_V
3. "Shortening of long vowels in various environments"
4. ans# > a:s#
5. [æ:] > [a:] / {e, i, r}
6. [æ:] > [ɛ:]
7. [w] > ø / C_

(viii) Tucker (1969)

1. [a:] > [æ:]
2. Vns > V:s
3. [w] > ø
4. Vowel contractions
5. Quantitative metathesis
6. [æ:] > [ɛ:]

(ix) 'First and second reopenings' – Lejeune (1972)

1. [a:] > [æ:]
2. [æ:] > [a:] / r_
3. [w] > ø / V_V
4. [ea] > [æ:]
5. [w] > ø / r_
6. [æ:] > [a:] / {e, i}
7. [æ:] > [ɛ:]

(x) Bubeník (1983)

1. [a:] > [æ:] – Attic only
2. Vrw > V:r – Attic only
3. [a:] > [æ:] – Ionic
4. [w] > ø / r_ - Ionic (no compensatory lengthening)
5. [æ:] > [ɛ:]

Appendix B

This appendix contains derivations of the forms in (3).

| | *korwa: 'maiden' | *argurea: 'silver' | *orea 'mountains' | *newa: 'new' | *k ^h reea 'matters' | *para:wa: 'cheek' | *ennewa 'nine' |
|----------------------------|---------------------|-----------------------|----------------------|-----------------|-----------------------------------|----------------------|-------------------|
| [a:] > [æ:] | korwæ: | argureæ: | | newæ: | | paræ:wæ: | |
| [eæ:] > [æ:] | | arguræ: | | | | | |
| [æ:]...[æ:] > [ɛ:]...[æ:] | | | | | | parɛ:wæ: | |
| [æ:] > [a:] / r_ | | argura: | | | | | |
| [ea] > [æ:] | | | ora: | | k ^h reæ: | | |
| [w] > ø | koræ: | | | neæ: | | pareæ: | ennea |
| [ɛ:] > [e] / _{æ:, a:, ɔ:} | | | | | | pareæ: | |
| [æ:] > [a:] / {i, e}_ | | | | nea: | k ^h rea: | parea: | |
| [æ:] > [ɛ:] | korɛ: | | ore: | | | | |
| | κόρη | ἀργυρᾶ | ὄρη | νέα | χρέᾶ | παρέᾶ | έννέα |

References

- Ahn, Sang-Cheol. 2004. Towards an optimal account of diachronic chain shifts II: French vowels. *Studies in Phonetics, Phonology, and Morphology* 10. 437-462.
- Allen, W. Sidney. 1974. *Vox Graeca: A guide to the pronunciation of classical Greek*. 2nd edn. London: Cambridge University Press.
- Antell, S.A., G.K. Cheron, B.L. Hall, R.M.R Hall, A. Myers, and M. Pam. 1973. Nilo-Saharan vowel harmony from the vantage point of Kalenjin. *Research Notes from the Department of Linguistics and Nigerian Languages, University of Ibadan, Nigeria* 6. 1-58.
- Anttila, Raimo. 1989. *Historical and comparative linguistics*. Amsterdam and Philadelphia: John Benjamins.
- Archangeli, Diana and Douglas Pulleyblank. 1994. *Grounded phonology*. Cambridge: MIT Press.
- Bartoněk, Antonín. 1966. *Development of the long-vowel system in ancient Greek dialects*. Prague: Státní pedagogické nakl.
- Del Barrio Vega, M. Luisa. 1990. Consideraciones sobre la evolución /ū/ > /ũ/ del Jónico-Atico, a partir del análisis de algunas formas euboicas. *Cuadernos de Filología Clásica, Ed. Universidad Complutense Madrid* 24. 175-183.
- Björck, Gudmund. 1950. *Das Alpha impurum und die tragische Kunstsprache: Attische Wort- und Stilstudien*. Uppsala: Almqvist & Wiksell.

- Blevins, Juliette. 2004. *Evolutionary phonology: The emergence of sound patterns*. New York: Cambridge University Press.
- Brandenstein, Wilhelm. 1954. *Griechische Sprachwissenschaft*. Berlin: Walter De Gruyter.
- Bubeník, Vít. 1983. *The phonological interpretation of Ancient Greek: A pandialectal analysis*. Toronto and Buffalo: University of Toronto Press.
- Buck, Carl Darling. 1965. *The Greek dialects: grammar, selected inscriptions, glossary*. Chicago and London: University of Chicago Press.
- Bynon, Theodora. 1977. *Historical linguistics*. Cambridge: Cambridge University Press.
- Calabrese, Andrea. 2000. The fronting of \bar{u} and the status of the feature ATR in Romance. In Lori Repetti (ed.), *Phonological Theory and the Dialects of Italy*, 59-88. Amsterdam: John Benjamins.
- Calabrese, Andrea. 2005. *Markedness and economy in a derivational model of phonology*. Berlin: Mouton de Gruyter.
- Campbell, Lyle and Jon Ringen. 1981. Teleology and the explanation of sound change. In Wolfgang U. Dressler, Oskar E. Pfeiffer, and John R. Rennison (eds.), *Phonologica 1980*, 57-67. Innsbruck: Institut für Sprachwissenschaft der Universität Innsbruck.
- Cauer, Paul. 1909. *Grundfragen der Homerkritik. 2nd edition*. Leipzig: S. Hirzel.
- Crothers, John. 1978. *Typology and universals of vowel systems. Universals of Human Language Vol. 2*, ed. by Joseph H. Greenberg. Stanford: Stanford University Press.
- Delattre, Pierre. 1971. Pharyngeal features in the consonants of Arabic, German, Spanish, French, and American English. *Phonetica* 23. 129-155.
- Dell, François and Oufae Tangi. 1993. On the vocalization of /r/ in Ath-Sidhar Rifian Berber. *Linguistica Communicatio* 5 (1-2). 5-53.
- Dressler, Wolfgang U. 1974. Diachronic puzzles for Natural Phonology. In Anthony Bruck, Robert A. Fox and Michael W. La Galy (eds.), *Papers from the Parasession on Natural Phonology*, 95-102. Chicago: Chicago Linguistic Society.
- Eliasson, Stig. 1992. Cognition in Phonological Change. In Günter Kellermann and Michael D. Morrissey (eds.), *Diachrony within Synchrony*, 283-308. Frankfurt and New York: P. Lang.
- Gates, H. Phelps. 1976. On the chronology of the Attic Rückverwandlung. *Glotta* 54. 44-52.

- Haudricourt, André-Georges and Alphonse G. Juilland. 1949. *Essai pour une histoire structurale du phonétisme français*. Paris: Klincksieck.
- Hock, Hans Heinrich. 1986. *Principles of historical linguistics*. Berlin and New York: Mouton de Gruyter.
- Jeffery, L. H. 1961. *The local scripts of archaic Greece; a study of the origin of the Greek alphabet and its development from the eighth to the fifth centuries B.C.* Oxford: Clarendon Press.
- King, Robert D. 1967. Functional load and sound change. *Language* 43. 831-352.
- King, Robert D. 1969a. *Historical linguistics and generative grammar*. Englewood Cliffs, N.J.: Prentice-Hall.
- King, Robert D. 1969b. Push chains and drag chains. *Glossa* 3. 3-21.
- Labov, William. 1994. *Principles of linguistic change volume 1*. Oxford: Blackwell.
- Labov, William. 2001. *Principles of linguistic change volume 2*. Oxford: Blackwell.
- Labov, William, Yaeger, Malcah and Richard C. Steiner. 1972. *A quantitative study of sound change in progress*. Philadelphia: U. S. Regional Survey.
- Labov, William, Ash, Sharon and Charles Boberg. 1997. A national map of the regional dialects of American English. http://www.ling.upenn.edu/phono_atlas/nationalmap/nationalmap.html (14 April 2017)
- Lass, Roger. 1976. Rules, metarules, and the shape of the Great Vowel Shift. In Roger Lass (ed.), *English phonology and phonological theory*, 51-102. Cambridge: Cambridge University Press.
- Lass, Roger. 1988. Vowel Shifts, great and otherwise: remarks on Stockwell and Minkova. In Dieter Kastovsky and Gero Bauer (eds.), *Luick revisited*, 395-410. Tübingen: Gunter Narr Verlag.
- Lasso de la Vega, José S. 1956. Sobre la historia de las vocales largas en griego. *Emérita* 24. 261-293.
- Lejeune, Michel. 1972. *Phonétique historique du mycénien et du grec ancien: Tradition de l'humanisme*, 9. Paris: Klincksieck.
- Lindau, Mona. 1975. *Features for vowels*. University of California, Los Angeles, CA: University of California dissertation.
- Malmberg, Bertil. 1964. *New trends in linguistics: An orientation*. Stockholm: Lund.
- Martinet, André. 1952. Function, structure, and sound change. *Word* 8. 1-32.
- Martinet, André. 1955. *Économie des changements phonétiques*. Bern: A. Francke.

- McCarthy, John J. 1994. The phonetics and phonology of Semitic pharyngeals. In Patricia Keating (ed.), *Papers in laboratory phonology III: Phonological structure and phonetic form*, 191-233. Cambridge, UK: Cambridge University Press.
- Méndez Dosuna, Julián. 1993. Los griegos y la realidad psicológica del fonema: κ y ϕ en los alfabetos arcaicos. *Kadmos* 32. 96-126.
- Peters, Martin. 1980. *Untersuchungen zur Vertretung der indogermanischen Laryngale im Griechischen*. Wien: Verlag der Österreichischen Akademie der Wissenschaften.
- Pierrehumbert, Janet B. 2001. Exemplar dynamics: word frequency, lenition and contrast. In Joan Bybee and Paul Hopper (eds.), *Frequency and the emergence of linguistic structure*, 137-57. Amsterdam and Philadelphia: John Benjamins.
- Rogers, Francis Millet. 1940. *The pronunciation of the Madeira and Azores dialects as compared with standard Portuguese*. Cambridge, MA: Harvard University dissertation.
- Ruipérez, Martín. 1956. Esquisse d'une histoire du vocalism grec. *Word* 12. 67-81.
- Samuels, Bridget D. 2006. *Nothing to lose but their chains: Rethinking vocalic chain shifting*. Cambridge, MA: Harvard University thesis.
- Schwyzler, Eduard, Brugmann, Karl, Geörgakas, Demetrios I., Debrunner, Albert and Fritz Radt. 1939. *Griechische Grammatik*. Munich: C.H. Beck.
- Sihler, Andrew L. 1995. *New comparative grammar of Greek and Latin*. New York: Oxford University Press.
- Smyth, Herbert Weir and Gordon M. Messing. 1956. *Greek grammar*. Cambridge, MA: Harvard University Press.
- Stockwell, Robert and Donka Minkova. 1997. On drifts and shifts. *Studia Anglica Posnaniensia* XXXI. 283-303.
- Sturtevant, Edgar Howard. 1920. *The pronunciation of Greek and Latin, the sounds and accents*. Chicago: University of Chicago Press.
- Szemerényi, Oswald. 1987. The Attic 'Rückverwandlung' or atomism and structuralism in action. In P. Considine and J.T. Hooker (eds.) *Scripta minora*, 1338-56. Innsbruck: Institut für Sprachwissenschaft der Universität Innsbruck.
- Teodorsson, Sven-Tage. 1974. *The phonemic system of the Attic dialect, 400-340 B.C.* Lund: Berlingska Boktr.
- Threatte, Leslie. 1980. *The grammar of Attic inscriptions, vol. 1: phonology*. Berlin and New York: Walter de Gruyter.

- Thumb, Albert and Anton Scherer. 1959. *Handbuch der griechischen Dialekte II*. Heidelberg: C. Winter.
- Trask, R. L. 1996. *Historical linguistics*. London and New York: Arnold.
- Tucker, R. W. 1962. On the dual pronunciation of *Eta*. *Transactions of the American Philological Association* 93. 490-501.
- Vaux, Bert. 1992. Adjarian's Law and consonantal ATR in Armenian. In J. Greppin (ed.), *Proceedings of the Fourth International Conference on Armenian Linguistics*, 271-293. New York: Delmar, Caravan Books.
- Walsh Dickey, Laura. 1997. *The phonology of liquids*. Amherst, MA: University of Massachusetts dissertation.
- Whalen, Douglas H. and Patrice S. Beddor. 1989. Connections between nasality and vowel duration and height: elucidation of the Eastern Algonquian intrusive nasal. *Language* 65. 457-486.