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DIONYSIUS OF HALICARNASSUS, *DE COMPOSITIONE VERBORUM* XI: RECONSTRUCTING THE PHONETICS OF THE GREEK ACCENT.

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> μουσικὴ γάρ τις ἦν καὶ ἡ τῶν πολιτικῶν λόγων ἐπιστήμη τῷ ποσῷ διαλλάττουσα τῆς ἐν ᾠδῇ καὶ ὀργάνοις, οὐχὶ τῷ ποιῷ· καὶ γὰρ ἐν ταύτῃ καὶ μέλος ἔχουσιν αἱ λέξεις καὶ ῥυθμὸν καὶ μεταβολὴν καὶ πρέπον, ὥστε καὶ ἐπὶ ταύτης ἡ ἀκοὴ τέρπεται μὲν τοῖς μέλεσιν, ἄγεται δὲ τοῖς ῥυθμοῖς, ἀσπάζεται δὲ τὰς μεταβολάς, ποθεῖ δ' ἐπὶ πάντων τὸ οἰκεῖον, ἡ δὲ διαλλαγὴ κατὰ τὸ μᾶλλον καὶ ἧττον.
>
> διαλέκτου μὲν οὖν μέλος ἑνὶ μετρεῖται διαστήματι τῷ λεγομένῳ διὰ πέντε ὡς ἔγγιστα, καὶ οὔτε ἐπιτείνεται πέρα τῶν τριῶν τόνων καὶ ἡμιτονίου ἐπὶ τὸ ὀξὺ οὔτ' ἀνίεται τοῦ χωρίου τούτου πλέον ἐπὶ τὸ βαρύ. οὐ μὴν ἅπασα λέξις ἡ καθ' ἓν μόριον λόγου ταττομένη ἐπὶ τῆς αὐτῆς λέγεται τάσεως, ἀλλ' ἡ μὲν ἐπὶ τῆς ὀξείας, ἡ δ' ἐπὶ τῆς βαρείας, ἡ δ' ἐπ' ἀμφοῖν. τῶν δὲ ἀμφοτέρας τὰς τάσεις ἐχουσῶν αἱ μὲν κατὰ μίαν συλλαβὴν συνεφθαρμένον ἔχουσι τῷ ὀξεῖ τὸ βαρύ, ἃς δὴ περισπωμένας καλοῦμεν· αἱ δὲ ἐν ἑτέρᾳ τε καὶ ἑτέρᾳ χωρὶς ἑκάτερον ἐφ' ἑαυτοῦ τὴν οἰκείαν φυλάττον φύσιν. καὶ ταῖς μὲν δισυλλάβοις οὐδὲν τὸ διὰ μέσου χωρίον βαρύτητός τε καὶ ὀξύτητος· ταῖς δὲ πολυσυλλάβοις, ἡλίκαι ποτ' ἂν ὦσιν, ἡ τὸν ὀξὺν τόνον ἔχουσα μία ἐν πολλαῖς ταῖς ἄλλαις βαρείαις ἔνεστιν. ἡ δ' ὀργανική τε καὶ ᾠδικὴ μοῦσα διαστήμασί τε χρῆται πλείοσιν, οὐ τῷ διὰ πέντε μόνον, ἀλλ' ἀπὸ τοῦ διὰ πασῶν ἀρξαμένη καὶ τὸ διὰ πέντε μελῳδεῖ καὶ τὸ διὰ τεττάρων καὶ ⟨τὸ διὰ τριῶν καὶ τὸν⟩ τόνον καὶ τὸ ἡμιτόνιον...
>
> (*De Compositione Verborum* 76.13 Usher)

This paper has two aims: first, to interpret and evaluate Dionysius' report of the pitch interval associated with the Greek word accent and to flesh out the skeletal information he offers with experimentally based typological data; and second, to supplement Dionysius' brief account of the tones of unaccented syllables with an analysis of the evidence of the Greek musical records for the phonetic implementation of both accented and unaccented syllables. This combination of ancient grammatical evidence with typological and philological data leads to a reconstruction of the tonal patterns of the Greek lexical word in its various sentential contexts.

1. The High-Low interval

1.1 The text[1]

Dionysius' argument is as follows: the distinction between speech, including oratorical delivery, and music is one of degree, not of kind: speech has melody and rhythm, just like music. The melody of speech uses one interval, namely the fifth—the pitch obtrusion associated with the accent does not exceed three tones and a semitone—whereas music additionally uses a variety of other intervals, such as the octave, the fourth, <the third,> the tone, and the semitone. On the face of it, one could hardly wish for a more valuable piece of evidence about the phonetics of the Greek accent. Apparently, one can conclude that if we could take a male Greek into a phonetics laboratory and ask him to say a sentence assigning a fundamental frequency of 123.5 Hz (B on the second octave of the tempered scale) to the lowest unaccented syllables, his fundamental frequency would rise on accented syllables to 185 Hz (F sharp on the third octave). We shall seek to establish to what extent such a conclusion can be drawn from Dionysius' report, and if it can, whether it is a believable conclusion. After all, ancient grammarians can give us what the Germans call a goldcorn or they can give us what the Americans call garbage. Nevertheless, Dionysius should be treated with the respect normally accorded a native informant. We cannot be sure that all characteristics of the word accent in the speech of educated Greeks at the time of Dionysius were identical to those of the classical period, but any qualifications on this score will be mitigated by the likelihood that Dionysius' report rests on an earlier grammatical tradition.

As a first step in the analysis, we need to be as clear as possible exactly what it is that Dionysius is trying to tell us; the text has its fair share of uncertainties of interpretation. Pitch excursions are measured (μετρέω) in intervals (διαστήματα): σμικρότατον...διάστημα ᾧ μετρητέον Plato, *Republic* 531a7, εἴτε μετρεῖταί τινι τῶν ἐλαττόνων διαστημάτων Aristoxenus, *Harmonics* I.24. There is no basis for the claim that μετρεῖται διαστήματι in Dionysius cannot refer to an interval defining a maximum range of pitch excursion: ἡ ἀνθρωπίνη φωνὴ μεμέτρηται φυσικῶς τῷ τρὶς διὰ πασῶν διαστήματι Anonymus Bellerman III.94. An additional restriction is introduced by the term ἑνί: music uses various intervals, but speech only one. This analysis is motivated by the doctrine of κίνησις συνεχής. Ancient tradition is quite explicit that in speech, as opposed to music, pitch is continuously changing: consequently the range of mid tones (τὸ διὰ μέσου χωρίον) intervening between the target peak and the target valley of a pitch excursion is not definable in terms of

[1] S. Usher, *Dionysius of Halicarnassus: The Critical Essays in Two Volumes* (Cambridge, Mass. 1985); G. Aujac and M. Lebel, *Denys d'Halicarnasse: Opuscules Rhétoriques* (Paris 1981); W. R. Roberts, *Dionysius of Halicarnassus: On Literary Composition* (London 1910). W. Corssen, *Aussprache, Vokalismus und Betonung der lateinischen Sprache* ed. 2, II (Leipzig 1870) 797; J. P. Postgate, *A Short Guide to the Accentuation of Ancient Greek* (London 1924); E. Sturtevant, *The Pronunciation of Greek and Latin* ed. 2 (Philadelphia 1940); J. Carson, "Greek Accent and the Rational," *JHS* 89 (1969) 24; W. Sidney Allen, *Vox Graeca* ed. 3 (Cambridge 1987) 120.

smaller intervals (nor, for most ancient treatments, are the targets themselves, since they too have insufficient duration). Aristides Quintilianus has a ternary distinction among κίνησις διαστηματική (music), κίνησις συνεχής (speech), κίνησις μέση (apparently a type of chant used for reading poetry):

> συνεχὴς μὲν οὖν ἐστι φωνὴ ἡ τάς τε ἀνέσεις καὶ τάς ἐπιτάσεις λεληθότως διά τι τάχος ποιουμένη. διαστηματικὴ δὲ ἡ τὰς μὲν τάσεις φανερὰς ἔχουσα, τὰ δὲ τούτων μεταξὺ [codd. μέτρα] λεληθότα, μέση δὲ ἡ ἐξ ἀμφοῖν συγκειμένη
> (*De Musica* I.4).

Pitch excursion in speech, Dionysius continues, does not have a range of more than three tones and a semitone from valley to peak nor from peak to valley. The implication of the terms πέρα and πλέον is not clear. They may simply imply that, given the larger intervals occurring in music, speech would a priori also be expected to allow such larger intervals. Or they may indicate that accentual excursions from peak to valley or vice versa of more than three tones and a semitone do not occur, but those of less than three tones and a semitone do occur. Accentual excursions would then vary from one instance to another of the word accent up to the maximum of a fifth. This interpretation is hard to reconcile with the whole point of Dionysius' argument, which is that pitch excursions in speech are restricted to a single interval, whereas music uses many different intervals. One possibility is that the ὀξύ and βαρύ refer to the accentual peak and valley of the largest accentual excursion in the utterance. Smaller accentual excursions would be discounted or treated as part of the κίνησις συνεχής rather than as measurable points for establishing the διαστήματα of speech. It is also conceivable that, at this point, Dionysius is having difficulty reconciling different and partially contradictory grammatical traditions.

It has also been suggested that the interval of a fifth is measured not from the lowest unaccented syllable to the accented syllable, and vice versa, but from a mean pitch or "midline" from which pitch is supposed to rise a fifth to the topline for accented syllables and fall a fifth to the bottomline for the lowest unaccented syllable. This midline hypothesis complicates the analysis by introducing a third measuring point into the κίνησις συνεχής of speech; since a διάστημα is, according to one of Bryennius's definitions, ὁδὸς ποιὰ ἀπὸ βαρύτητος εἰς ὀξύτητα ἢ ἀνάπαλιν, the midline would represent a βαρύ for the ἐπίτασις and an ὀξύ for the ἄνεσις. It has also been argued that on the usual interpretation, the phrase οὔτ' ἀνίεται...πλέον is tautologous with what precedes, but, quite apart from the implied judgment about the rarity of tautology in ancient grammatical writings, this is not so unless pitch inevitably falls by just the same amount that it has previously risen, which is not the case. On the other hand, it has been suggested that ἀνίεται τοῦ χωρίου τούτου πλέον means "falls from this pitch level to a greater extent" rather than "falls more than this pitch range," a suggestion that is incompatible with the midline hypothesis. However, in geometrical terminology χωρίον refers to an area, particularly a rectangle (ἔστιν οὖν τετράγωνον χωρίον Plato, *Meno* 82b), and with the phrase τὸ διὰ μέσου χωρίον βαρύτητός τε καὶ ὀξύτητος a few lines down Dionysius seems to be denoting the pitch range between the βαρύ and the ὀξύ rather than a single intermediate tone.

This is about as far as the discussion can be taken on the basis of textual analysis alone. Dionysius' evidence for the phonetics of the Greek accent now needs to be interpreted in the overall framework of what is known about how tone is produced and perceived in speech; otherwise, there is a danger that any interpretation will be limited to an abstract and superficial exercise in deduction unconnected with the physical realities it seeks to clarify.

1.2. The production of tone[2]

This section briefly surveys the main factors that can influence the fundamental frequency excursion associated with a word accent. These factors are important for an appreciation of the acoustic events that underlie Dionysius' account of the Greek accent and consequently, when taken in conjunction with the data on perception in the next section, for the interpretation of that account. Intervals reconstructed for Greek are provisionally viewed as involving measurement of fundamental frequency from peak to valley rather than some other theoretically conceivable measure such as mean or midpoint fundamental frequency. The terms High, Mid and Low, as they refer to tones, are used throughout this paper as a first level of phonological abstraction to indicate the general phonetic level of a tone; no ultimate phonological analysis in terms of a minimal specification of target tones is implied. The actual peak to valley excursions found in speech do not necessarily correspond to pure musical intervals, that is they often cannot accurately be expressed by a simple numerical ratio; however, it may be that the frequency of pure intervals was higher in Greek than it is in English, since one study found about twice as many pure intervals in Norwegian, which has a tonal accent, as in English.[3]

High vowels have greater intrinsic fundamental frequency than low vowels. This difference has been established for a variety of languages: for instance, a study on English found a difference of 12–16 Hz;[4] in Danish a range of 10–35 Hz was found.[5] Intrinsic fundamental frequency differences are more marked where pitch is boosted by other factors, that is at the beginning of an utterance and in emphasized syllables: in such contexts differences in English of about 2

[2] D. R. Ladd, "Declination: a Review and Some Hypotheses," *Phonology Yearbook* 1 (1984) 53. M. Liberman and J. Pierrehumbert, "Intonational Invariance under Changes in Pitch Range and Length," *Language Sound Structure*, ed. M. Aronoff and R. T. Oehrle (Cambridge, Mass. 1984) 157. W. J. Poser, *The Phonetics and Phonology of Tone in Japanese* (Ph.D. diss. MIT 1985). J. Pierrehumbert and M. Beckman, *Japanese Tone Structure* (Cambridge, Mass. 1988).

[3] I. Lehiste, *Suprasegmentals* (Cambridge, Mass. 1970) 81. For some speculation on musical intervals in speech see D. Hirst, "Phonological Implications of a Production Model of Intonation," *Phonologica 1980* ed. W. U. Dresler, O. E. Pfeiffer, and J. R. Rennison, 195 (Innsbruck 1981).

[4] G. E. Peterson and H. L. Barney, "Control Methods Used in the Study of Vowels," *JASA* 24 (1952) 175.

[5] N. R. Petersen, "Intrinsic Fundamental Frequency of Danish Vowels," *JPh* 6 (1978) 177.

to 3 semitones were found as compared with about 0.5 to 1.5 semitones in other contexts.[6] The reason for the difference in intrinsic fundamental frequency of vowels has been the subject of intense investigation: one possibility is that when the tongue is raised for the articulation of high vowels, it exerts extra tension that is, in one way or another, transmitted to the vocal cords and consequently induces higher fundamental frequency[7]. It is easy to see that the differences just cited are large enough to make a considerable impact on Dionysius' reported interval of a fifth, particularly when cases in which the interval is increased by intrinsic fundamental frequency boosting the peak and further lowering a contiguous valley are compared with cases showing the inverse relation that constricts the interval. However, it is likely that differences of intrinsic pitch were somewhat less extensive in Greek than they are in English, because they seem to be inversely correlated with the functional load of pitch in a language and/or positively correlated with the physiological effort associated with stress: the differences have been found to be smaller in the tone language Itsekiri than in the pitch-differentiated stress language Serbocroat, and smaller in Serbocroat than in the simple stress language English. The suggestion[8] that a passage of the *Poetics*—τὰ στοιχεῖα διαφέρει...ὀξύτητι καὶ βαρύτητι 1456b—refers to intrinsic pitch rather than accentual pitch is very unlikely, cp. Priscian III.519.10 Keil: "habet quippe littera altitudinem in pronuntiatione." The potential relevance of intrinsic fundamental frequency of vowels in Greek music is tested in section 2.3.1 below.

The fundamental frequency of a vowel is also liable to be influenced by the presence or absence of voice in a preceding stop consonant.[9] Except immediately following the stop release, fundamental frequency tends to be falling from an absolute higher value after voiceless stops and level or rising from an absolute lower value after voiced stops, although some reports of rising fundamental frequency after voiced stops may be owing to a failure to factor out the intonational context. In Swedish, peak fundamental frequency was found to be 15 Hz lower and 25 msec later into the vowel after voiced than after voiceless consonants.[10] The physiological basis for this is again poorly understood; one interpretation supposes a difference in tension of the vocal cords associated with consonant voicing.[11] The effect weakens as the vowel progresses; it also lasts

[6] S. A. Steele, *Vowel Intrinsic Fundamental Frequency in Prosodic Context* (Ph.D. Diss. Texas 1985).

[7] The most recent discussion we have seen is E. Vilkman, O. Aaltonen, I. Raimo, P. Arajärvi and H. Oksanen, "Articulatory Hyoid-Laryngeal Changes *vs.* Cricothyroid Muscle Activity in the Control of Intrinsic F_0 of Vowels," *JPh* 17 (1989) 193.

[8] Carson (above, note 1).

[9] For recent discussions see J. C. Kingston, *The Phonetics and Phonology of the Timing of Oral and Glottal Events* (Ph.D. diss. Berkeley 1984); R. Ohde, "Fundamental Frequency as an Acoustic Correlate of Stop Consonant Voicing," *JASA* 75 (1984) 224; K. Silverman, "F_0 Cues Depend on Intonation," *Phonetica* 43 (1986) 76.

[10] A. Löfqvist, "Intrinsic and Extrinsic F_0 Variations in Swedish Tonal Accents," *Phonetica* 31 (1975) 228.

[11] A. Löqvist, T. Baer, N. S. McGarr and R. S. Story, "The Cricothyroid Muscle in Voicing Control," *JASA* 85 (1989) 1314–21.

longer into the vowel in English than in tone languages such as Thai,[12] Yoruba,[13] and Hausa,[14] where it is a comparatively transient effect. In a number of African tone languages, voiced obstruents have the phonological effect of lowering the tones of contiguous vowels, and in such cases they are called 'depressor consonants'.[15] In Japanese, the pitch peak in accented syllables occurs later after voiced stops than after voiceless stops.[16] We are probably justified in concluding that the cumulative impact of these segmental factors on the fundamental frequency of an accentual excursion in Greek, for instance in πίθος versus βάθος, or sequentially in ἐπίβασις, would certainly be fairly substantial: in English, a difference of 30 Hz was found between the peak fundamental frequencies of [pi] and [bæ].[17] The potential relevance of the effect of preceding stop voicing on fundamental frequency in Greek music is tested in section 2.3.1 below. A small but consistent difference in fundamental frequency is also occasioned by the voice of a following obstruent;[18] although this difference can be used as a perceptual cue, it is minor compared with the effect of the voice of a preceding obstruent and is discounted in the following analysis.

Another factor that presumably affects the magnitude of an accentual excursion is the number of pre- and postaccentual morae or syllables in the word. Theoretically, three situations can be envisaged: *either* the target peak and/or the target valley are fixed and the slope from one to the other varies according to the number of unaccented syllables, *or* the slope is fixed and the targets vary, *or* both the targets and the slope vary. In Japanese, the valley, and, to a smaller degree, the following and preceding peaks are sensitive to the number of postaccentual morae: the greater the number of postaccentual morae, the lower the valley and the higher the preceding peak; moreover, the peak of the following minor phrase is somewhat lower after a deep valley than after a shallow valley; none of these effects generally exceeded 15Hz for a male speaker, and there may be an absolute limit beyond which a valley cannot be depressed to accommodate additional postaccentual morae.[19] In Danish, the degree of pitch rise onto the posttonic syllable is sensitive to the number of unstressed syllables following

[12] J. Gandour, "Consonant Types and Tone in Siamese," *JPh* 2 (1974) 337.

[13] J. M. Hombert, "Consonant Types, Vowel Quality, and Tone," *Tone: A Linguistic Survey*, ed. V.A. Fromkin (New York 1978) 77.

[14] L. Myers, *Aspects of Hausa Tone. Working Papers in Phonetics*, UCLA no. 32 (1976).

[15] J. A. Goldsmith, *Autosegmental and Metrical Phonology* (Oxford 1990).

[16] H. Kawasaki, "Fundamental Frequency Perturbation Caused by Voiced and Voiceless Stops in Japanese," *JASA* 73 (1983) S88.

[17] I. Lehiste and G. E. Peterson, "Some Basic Considerations in the Analysis of Intonation," *JASA* 33 (1961) 419. Intrinsic and contextual fundamental frequency have been found to combine or neturalize each other in French too: A. Di Cristo and D. J. Hirst, "Modelling French Micromelody: Analysis and Synthesis," *Phonetica* 43 (1986) 11.

[18] K. E. A. Silverman, "The Separation of Prosodies," *Papers in Laboratory Phonology I*, ed J. Kingston and M. E. Beckman (Cambridge 1990) 139.

[19] H. Kubozono, *The Organization of Japanese Prosody*. Ph.D. diss., University of Edinburgh. 1987.

the accent. The evidence for such variation in Greek is analyzed in section 2.3.3 below.

When rapid speech is compared with slow speech, and when connected speech having tonal coarticulation is compared with citation form pronunciations, significant differences are found in the execution of the movement between target tones: pitch range can be compressed (that is, peaks can be lowered and valleys raised), complex movements can be replaced by simpler movements, and the association of target tones with segments can be changed. Such phenomena have been investigated in Swedish,[20] Japanese,[21] and Chinese.[22] Pitch sandhi effects in Greek are analysed in section 2.3.4 below.

When other pitch modifying features are factored out, almost all languages have an overall decrease in fundamental frequency from the beginning to the end of a declarative utterance. Languages in which some form of downtrend is absent are extremely rare, although the phenomenon seems to be more marked in sentences read under experimental conditions than in ordinary discourse.[23] Downtrend can be analyzed as arising from three separate contributing factors: declination, which is a tendency for fundamental frequency to fall gradually as the utterance progresses; catathesis, as it is generally termed nowadays, which is a resetting of fundamental frequency in alternating High-Low structures; and terminal fall, which is a significant additional lowering of fundamental frequency at the end of a domain. Declination has been estimated to contribute to downtrend at a very approximate rate of 10 Hz per second. Terminal fall at the end of an utterance can produce a steep fall in fundamental frequency to the point of laryngealization, and the lowering effect can spread backwards into nonfinal syllables. Catathesis is the major contributor to downtrend: one of the consequences of catathesis is that in a tone language a High tone late in the utterance can have lower fundamental frequency than a Low tone earlier in the same utterance, and in an accent language, an accented syllable late in the utterance can have lower fundamental frequency than an unaccented syllable earlier in the utterance. The physiological basis of downtrend apparently involves both action of laryngeal muscles and declining subglottal air pressure.[24]

[20] E. Gårding and J. Zhang, "Temporal and Prosodic Pattern in Chinese and Swedish," *WPGLP* Lund University 31 (1987) 11.

[21] Y. Nagano-Madsen, "Effect of Temporal Tonal Context on Fundamental Frequency Contours in Japanese," *WPGLP* Lund University 31 (1987) 103.

[22] C.-L. Shih, "Tone and Intonation in Mandarin," *Working Papers of the Cornell Phonetics Laboratory* 3 (1988) 83–109.

[23] W. E. Cooper, S. J. Eady and P. R. Mueller, "Acoustical Aspects of Contrastive Stress in Question-Answer Contexts," *JASA* 77 (1985) 2142.

[24] For recent discussions see R. Collier, "F_0 Declination: The Control of its Setting, Resetting, and Slope," *Laryngeal Function in Phonation and Respiration*, ed. T. Baer, C. Sasaki and K. S. Harris (Boston 1987) 27; C. E. Gelfer, *A Simultaneous Physiological and Acoustic Study of Fundamental Frequency Declination.* PhD. Dissertion. CUNY 1987.

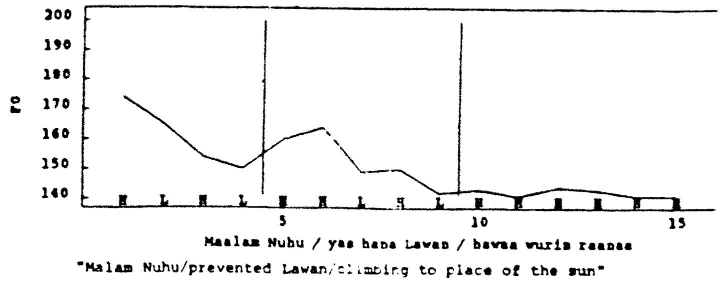


Figure 1:
Tonal Downtrend in a Hausa Declaration [25]

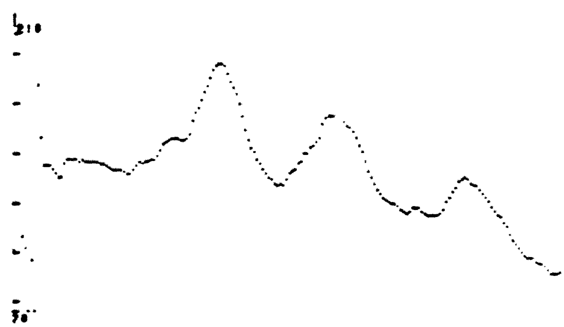


Figure 2:
Pitch accent catathesis in a Japanese declaration, *Sore wa nurúi umái nomímono*[26]

[25] Reproduced in modified form by permission of W. R. Leben. See S. Inkelas and W. R. Leben, "Where Phonology and Phonetics Intersect: The Case of Hausa Intonation," *Papers in Laboratory Phonology I*, ed. J. Kingston and M. E. Beckman (Cambridge 1990) 17.

[26] Reproduced with permission from Poser (above, note 2).

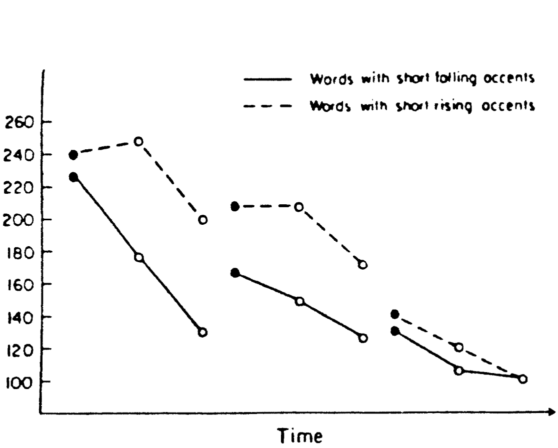


Figure 3:
Downtrend with pitch-differentiated stress accents in sentences consisting of three trisyllabic words in Serbocroat, *Jàgnje se dàruje bàbama* with short falling accents and *Snàšice ràznose tràvicu.*[27]

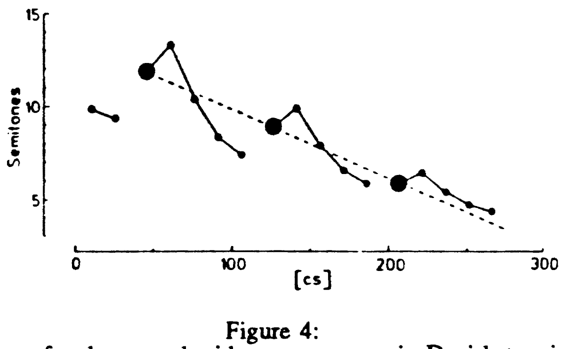


Figure 4:
Schema for downtrend with stress accents in Danish terminal declarative utterances. Large dots represent stressed syllables, small dots unstressed syllables.[28]

[27] Reproduced with permission from I. Lehiste and P. Ivíc, *Word and Sentence Prosody in Serbocroatian* (Cambridge, Mass. 1986).

[28] Reproduced in modified form with permission of N. Thorsen. See, e.g., N. Thorsen, "Two Issues in the Prosody of Standard Danish," *Prosody: Models and Measurements*, Ed. A. Cutler and D. R. Ladd (Berlin 1983) 27.

Downtrend is illustrated for a tone language (Hausa) in Figure 1, for a pitch accent language (Japanese) in Figure 2, for a pitch differentiated stress language (Serbocroat) in Figure 3, and for a stress language (Danish) in Figure 4. The effects of catathesis are dramatic whether the High-Low sequence is tonal or accentual. In Danish, the pitch peak is actually dislocated one syllable to the right of the stress onto the first unaccented syllable. Since catathesis does not only lower frequency but also compresses the frequency range of accentual excursions, the peak to valley and valley to peak measurements will be smaller toward the end of a catathesis domain than at the beginning. Some of this difference is absorbed with the change from a linear frequency scale in Hertz to a logarithmic pitch scale in semitones, but a significant difference can remain, as is overtly shown in Figure 4 in which the scale is in semitones.[29] The evidence from Greek vocal music for downtrend in Greek speech is analyzed in section 2.3.5 below.

The phenomenon of downtrend complicates our exploitation of Dionysius' evidence for the purposes of reconstructing the accentual excursions in a Greek sentence. One possible assumption would be that Dionysius is reporting the central values likely to occur around the midpoint of a catathesis domain, and that we should increase his reported interval of a fifth to reconstruct the comparatively large falls at the beginning of the domain and correspondingly decrease it after the midpoint in the domain. However, to the extent that the data cited so far contain representative intervals, they suggest that an excursion of as much as a fifth would be more likely to occur at or close to the beginning of an utterance with catathesis. For instance, the fundamental frequency contour illustrating downtrend in Japanese (Figure 2) has peak to valley ratios starting at 150% (a fifth) and falling about 10% per pitch accent to approximately 125% (a major third), factoring out the additional terminal fall. In Dutch, which is a stress language, accentual prominence rarely involves excursions of more than half an octave in normal, nonemphatic speech.[30] Another possibility is that Dionysius' report is based on words uttered in isolation. An early study of Kyoto Japanese disyllables reported a difference of just under a fifth in paroxytone words.[31] It is also interesting that in Thai words uttered in isolation the pitch excursions involved in the falling and rising lexical tones were typically just under a fifth.[32] This view involves two difficulties. It is not clear to what extent Dionysius has discounted the additional terminal pitch fall which characterizes the end of words uttered in isolation, and which, if included, would, even by

[29] It is interesting that in long sentences in Hausa, although frequency excursions are in a higher register in the first phrase than in the last, the intervals between High and Low are greater in the last phrase than in the first: R. O. Silverstein, "A Strategy for Utterance Production in Hausa," *Studies in African Linguistics* Suppl. 6 (1976) 233.

[30] J. 't Hart, "Differential Sensitivity to Pitch Distance, Particularly in Speech," *JASA* 69 (1981) 811.

[31] Y. Homma, "An Acoustic Study of Japanese Vowels," *The Study of Sounds* 16 (1973) 347.

[32] A. S. Abramson, "Static and Dynamic Cues in Distinctive Tones," *Language and Speech* 21 (1978) 391. J. S. Gandour and S. H. Petty, "Perception and Production of Tone in Aphasia," *Brain and Language* 35 (1988) 201.

itself, result in a sizeable discrepancy between ἐπίτασις and ἄνεσις. Studies of Japanese words uttered in isolation have found rather steep postaccentual falls.[33] Furthermore, as far as we can tell, utterances, including words in citation form, tend not to start with a fully low tone but with some form of mid tone. For instance, in Kinyarwanda (a tone language in which the tones have become so restricted that they pattern as in a pitch accent language), the tonal sequence High High High when uttered in isolation is modified to Mid High Low, rather than Low High Low or Low High Mid.[34] It seems to be Dionysius' implicit assumption that rise and fall involved identical intervals, although the text does not explicitly say so. But the view that Dionysius' report is based on words in their citation form does not fit too well with this assumption. The evidence from Greek vocal music for a Mid High Low pattern of words in Greek speech is analyzed in section 2.3.3 below.

Downtrend is conditioned by the overall pitch range chosen by the speaker. When subjects in an experiment are instructed to "speak up," reflecting a greater degree of overall emphasis or excitement, not only do the absolute values of accentual peaks significantly increase, but the intervals between consecutive peaks, expressed logarithmically, also increase. If this is also true for the peak to valley intervals that Dionysius is concerned with, then it is a legitimate question whether the pitch range he is referring to is the normal conversational register or the higher register that would characterize ordinary, unexaggerated (not more Asiatico) rhetorical declamation, given Dionysius' profession and the stated objectives of his book.

In addition to the overall variation in the pitch range attributable to downtrend, there is also the factor of local variation, taking the shape of a localized increase in pitch level and pitch intervals to convey focus or emphasis on a particular word or phrase; this is typically done to separate new information contributed by a sentence to the discourse from old and already established information or to pinpoint semantic material involved in a contrast or an erroneous assumption. The emphasized material is given greater duration, intensity and pitch obtrusion, and neighbouring pitch excursions tend to be constricted. Pitch obtrusion as one implementation of emphasis is not confined to stress languages such as English, but is well established also in tone languages such as Zulu, Hausa, Thai and Chinese, in pitch differentiated stress languages such as Serbocroat and in the pure pitch accent language Japanese. Japanese relies more on word order and particles than English does, but expansion of the pitch range is also found. In Hausa, focused material that is not fronted regularly receives special intonation.[35] In Japanese, a boost of approximately 20 Hz from 165 to 185 Hz was found for emphasized as compared with unemphasized adjectives.[36] In Serbocroat, the interval between the peak frequency of the accented first

[33] H. Fujisaki and M. Sugito, "Acoustic and Perceptual Analysis of Two-Mora Word Accent Types in the *Osaka* Dialect," *Annual Bulletin, Research Institute of Logopedics and Phoniatrics* 10 (1976) 157.

[34] R. Furere and A. Rialland, "Tons et accents en Kinyarwanda," *African Linguistics: Essays in Memory of M. W. K. Semikenke*, ed. D. L. Goyvaerts (Amsterdam 1985) 99.

[35] S. Inkelas, *Prosodic Constituency in the Lexicon*. Ph.D. diss. Stanford, 1989.

[36] Poser (above, note 2).

syllable and the terminal frequency of the postaccentual syllable in the second word in a sentence increased from 40 Hz without emphasis to 130 Hz with maximum emphasis.[37] The evidence from Greek vocal music for pitch obtrusion as an implementation of emphasis in Greek speech is analyzed in section 2.3.7.1 below.

A few other factors deserve brief mention. In longer utterances, downtrend can be reset at phrase boundaries, normally restarting at a lower level than at the beginning of the utterance. The evidence from Greek vocal music for the reset of downtrend at phrase boundaries in Greek speech is analyzed in section 2.3.6 below. Sequences of short sentences can also be arranged into hierarchical downtrend structures; when a single sentence was compared with a three-sentence structure in Swedish, it was found that the peaks and valleys of the single sentence were lower than those of the initial sentence of the three-sentence structure and higher than those of the final sentence.[38] The internal syntactic or prosodic structure of a catathesis chain can also affect the patterns of downtrend.[39] The evidence from Greek vocal music for the effect of syntactic structure on downtrend in Greek speech is discussed in sections 2.3.6 and 2.3.7.1 below. Terminal pitch fall in declarative utterances has already been alluded to. Downtrends are likely to be constrained in at least some types of interrogative sentences, and there may be a terminal rise: in Japanese there is a steep rise in pitch on the final syllable of a yes-no question of 110 Hz or more.[40] Questions can also have a higher overall pitch range.[41] In one study on English, for male subjects saying monosyllabic words with rising (interrogative) intonation, e.g. "me?", "John?", fundamental frequency rose from 118 to 265 Hz, which is well over an octave; for the same monosyllables with falling (declarative) intonation, fundamental frequency fell from 159 to 102 Hz, which is just over a fifth.[42]

Our evaluation of Dionysius' evidence and our use of it to reconstruct the phonetics of the Greek accent will depend in part on the extent to which we can assume he is abstracting away from rather than averaging in the skewing effects of any or all of the factors just discussed.

1.3. The perception of tone[43]

Up to now, we have been concerned with the acoustic properties of the Greek accent in its various contexts. We must now give some consideration to the question of how and to what extent Dionysius, as a Greek listener, would be aware of those varying acoustic properties and therefore in a position to take account of them in his description of the Greek accent.

37 Lehiste et al. (above, note 27).

38 G. Bruce, "Textual Aspects of Prosody in Swedish," *Phonetica* 39 (1982) 274.

39 H. Kubozono, "Syntactic and Rhythmic Effects on Downstep in Japanese," *Phonology* 6 (1989) 39.

40 Poser (above, note 2).

41 Inkelas et al. (above, note 25).

42 R. B. Monsen and A. M. Engebretson, "Study of Variations in the Male and Female Glottal Wave," *JASA* 62 (1977) 981.

43 't Hart (above, note 30). Hombert (above, note 13). M. E. Beckman, *Stress and Nonstress Accent* (Dordrecht 1986) 107. A. C. M. Rietveld and C. Gussenhoven, "On the Relation between Pitch Excursion Size and Prominence," *JPh* 13 (1985) 299–308.

People who can tell the pitch of a single pure tone to within a semitone are comparatively rare. But many people who do not have absolute pitch can tell whether two sequentially presented tones have identical frequencies or not: for tones in the region of 1000 Hz, just noticeable differences can be below 1 Hz. With synthetic vowels having constant fundamental frequency throughout their duration, it was found that listeners were likewise able to perceive differences of less than 1 Hz,[44] but, when frequency is changing, as it normally is in real speech situations, just noticeable differences were in the order of 2 to 2.5 Hz.[45] In another study, adjacent syllables were found to differ perceptually in pitch if they were 5% or a little less than a semitone apart.[46] The accuracy with which people can differentiate two consecutively presented pitch intervals is obviously relevant to any description of word accents. Subjects showed notable variation in their capabilities and in their strategies in this task, with the most successful performers able to discriminate differences as low as 1.5 semitones. A peak height difference of 1.5 semitones was also sufficient to create a perceptible difference in the prominence of a Dutch focus accent. These results pertain to the question whether the factors mentioned in the previous section as potentially conditioning fundamental frequency have effects large enough to impact on the intervals reported by Dionysius.

Identical intervals in semitones have been found to be subjectively larger at higher frequencies than at lower frequencies.[47] The direction of fundamental frequency change also seems to affect the perception of the magnitude of the interval. The change in pitch perceived for a rising fundamental frequency excursion is greater than that for a falling excursion of the same magnitude.[48] This fact may provide some justification for assuming that fundamental frequency fell more from the accentual peak than it rose to it, despite the probable implication of Dionysius' text that the rise and the fall were of equal magnitude.

Provided the magnitude of a frequency change and the duration of the transition are not too large, a single unchanged pitch will be attributed to a vowel having continuously rising or falling fundamental frequency. According to one study, if the fundamental frequency excursion was less than about 2.5 semitones, a single pitch was assigned to the vowel corresponding to the frequency approximately two-thirds of the way into the excursion.[49] This perceptual effect potentially complicates the simple procedure adopted in the preceding section of reconstructing intervals in terms of peak and valley measurements.

At a less physical and more linguistic level of perception, we need to ask whether Dionysius is including in his reported intervals differences in

44 J. L. Flanagan and M. G. Saslow, "Pitch Discrimination for Synthetic Vowels," *JASA* 30 (1958) 435.

45 D. H. Klatt, "Discrimination of Fundamental Frequency Contours in Synthetic Speech," *JASA* 53 (1973) 8.

46 A. V. Isačenko and H. J. Schädlich, *A Model of Standard German Intonation* (The Hague 1970).

47 Rietveld and Gussenhoven (above, note 43).

48 See Beckman (above, note 43) 116.

49 M. Rossi, "Le seuil de glissando ou seuil de perception des variations tonales pour les sons de la parole," *Phonetica* 23 (1971) 1. Id. "La perception des glissandos descendants dans les contours prosodiques," *Phonetica* 35 (1978) 11.

fundamental frequency that listeners can hear but partially or completely discount as linguistically insignificant.

There seems to be an intrinsic pitch effect inversely correlated with the intrinsic fundamental frequency effect noted above for vowels and partially compensating for it. When speakers of English were presented with low and high vowels (*a* versus *i*, *u*) having the same fundamental frequency and instructed to judge which one had the higher pitch, they chose the low vowel two and a half times as often as the high vowel.[50] However, the intrinsic fundamental frequency of vowels can be exploited in whistle languages, as at Kusköy in Turkey, where *a* is whistled at 1750 Hz, *e* at 2100 Hz and *i* at 2600 Hz.[51] In the drum language of San Cristoval in the Solomon Islands, a low-toned drum is used to represent *a* and a high-toned drum for the mid and high vowels *e, o, i, u*.[52]

The perceptual effects of consonant voicing on vowel pitch can be expected to be less significant because of the comparatively transient nature of the resulting fundamental frequency perturbations. Nevertheless, they can serve as a cue to consonant voicing,[53] and comparable differences in synthetic vowel stimuli can be heard as small differences in pitch. In the Zulu praise poems, which are chanted in the upper pitch range of the performer's voice, consonant voicing can affect the note assigned to a syllable.[54]

There is also evidence that listeners partially correct for downtrend effects when estimating pitch. When subjects were asked to judge which of two stressed syllables in a nonsense sentence was higher in pitch, the configuration for which their answers were random actually had 10 Hz lower fundamental frequency on the second stressed syllable; there was also a correction for the pitch range factor.[55] Nevertheless, in Subsaharan Africa, where most tone languages have downdrift, musical melodies are often reported to be characterized by a predominantly downward slope. For instance, the highest note in a typical Igbo

50 Hombert (above, note 13). C. K. Chuang and W. S. Wang, "Psychophysical Pitch Biases Related to Vowel Quality, Intensity Difference, and Sequential Order," *JASA* 64 (1978) 1004; G. Stoll, "Pitch of Vowels: Experimental and Theoretical Investigations of its Dependence on Vowel Quality," *Speech Communication* 3 (1984) 137–50.

51 C. Leroy, "Etude de phonétique comparative de la langue turque sifflée et parlée," *Revue de phonétique appliquée* 14–15 (1970) 119.

52 J. Snyders, "Le langage par tambours à San Cristoval, British Solomon Islands," *Journal de la société des océanistes* 24 (1969) 133.

53 M. Haggard, S. Ambler and M. Callow, "Pitch as a Voicing Cue," *JASA* 47 (1970) 613. The perceptual system is apparently elastic enough to "hear" intrinsic and contextual fundamental frequency effects for segmental identification and to discount them for prosodic purposes: R. Petersen, "Perceptual Compensation for Segmentally Conditioned Fundamental Frequency Perturbation," *Phonetica* 43 (1986) 31.

54 D. Rycroft, "Melodic Features in Zulu Eulogistic Recitation," *African Language Studies* 1 (1970) 60. Id., "Zulu and Xhose Praise-Poetry and Song," *African Music* 3.1 (1972) 79.

55 J. Pierrehumbert, "The Perception of Fundamental Frequency Declination," *JASA* 66 (1979) 363. C. Gussenhoven and A. C. M. Rietveld, "Fundamental Frequency Declination in Dutch: Testing Three Hypotheses," *JPh* 16 (1988) 355.

melody is the first High tone, after which the tune works its way down to the end.[56]

In the above discussion, we have tried to provide the reader with the information needed for making a decision about the meaning and the value of Dionysius' evidence. It is clear that Dionysius has abstracted away from a variety of effects that condition accentual excursions in the acoustic records of living languages. The reported interval of a fifth conforms quite well to the upper end of the range of intervals associated with ordinary, unemphatic accentual prominence, but it does not conform at all with the overall frequency range of an utterance measured from the peak of the highest prominence to the lowpoint of the terminal fall, a measurement which can easily exceed an octave. This suggests that Dionysius' report pertains to the domain of the word, and not to the domain of the utterance. The ὀξύ and the βαρύ separated by a fifth are in the same word; they are not the highest ὀξύ and the lowest βαρύ in the utterance. For Dionysius to assign the single interval of a fifth to accentual excursions that in fact varied considerably is a natural generalization that could equally well be made by nonexperimental field investigators nowadays. The interval of a fifth seems to fit best with the first accentual fall in the utterance, or with the fall in a citation form allowing the possibility of some factoring out of terminal fall. On the other hand, the midline hypothesis, which we do not favour, is unrealistic for the domain of the word and can only be adopted for the domain of the utterance.

2. Reconstruction of the pitch movements of Greek speech on the basis of the Delphic Hymns

2.1. The phonetic implementation of accented and unaccented syllables

Dionysius tells us that in Greek there is only one high toned syllable per accented word: ἡ τὸν ὀξὺν τόνον ἔχουσα μία. The other syllable in the case of a disyllabic word, and the other syllables in the case of polysyllabic words, are low toned: ἐν πολλαῖς ταῖς ἄλλαις βαρείαις; the same tradition appears in Pseudo-Sergius IV.532.10K: graves numero sunt plures. He also tells us that in disyllabic words there is no Mid tone: ταῖς μὲν δισυλλάβοις οὐδὲν τὸ διὰ μέσου χωρίον βαρύτητος τε καὶ ὀξύτητος. That polysyllables do have Mid tones follows logically and is clearly suggested by the antithesis ταῖς μὲν δισυλλάβοις...ταῖς δὲ πολυσυλλάβοις; whether these Mid tones are the notorious *prosodia media* is a separate question.[57] βαρύς means unaccented phonologically and low toned (as opposed to mid toned) phonetically. Dionysius' report provides clear confirmation that in Greek none of the unaccented syllables is high toned; Greek is not like Tokyo Japanese, in which all morae between the first and the accentual fall are phonologically high toned. But Dionysius

[56] L. E. N. Ekwueme, "Linguistic Determinants of Some Igbo Musical Properties," *Journal of African Studies* 1 (1974) 355. Id., "Analysis and Analytic Techniques in African Music," *African Music* 6 (1980) 89.

[57] E. Pöhlmann, "Der Peripatetiker Athenodor über Wortakzent und Melodiebildung im Hellenismus," *WSt* 79 (1966) 201.

does not tell us how the Mid and Low tones are distributed in unaccented syllables. Does fundamental frequency rise gradually to the accentual peak and fall gradually from the peak? or is the accentual fall concentrated in the postaccentual mora or syllable? Is the lowest postaccentual tone normally the final syllable of the word? Is the lowest tone a fixed target or does it vary according to the number of postaccentual morae? Can the lowpoint be anticipated or postponed in sandhi environments? Is it possible to draw a straight line connecting the measurement points of the fundamental frequency of unaccented syllables? or would the line have kinks in it, as would happen if any syllable carried more than its proportional share of the rise or fall? Is the lowest preaccentual tone the same as the lowest postaccentual tone of the preceding word or higher or lower?

One might think that the answers to such questions are beyond our grasp, seeing that it is not possible to conduct in vivo experimental studies on a dead language. However, the surviving musical records, particularly the Delphic hymns, provide a valuable in vitro source of evidence that compensates to some considerable degree for the lack of experimental measurements. We shall see that careful and detailed analysis of the musical records, including statistical evaluation where possible, can provide answers to the questions just posed. This method will also be used to resolve problems associated with accented syllables, specifically to estimate the tonal height of the grave accent and to test for direct evidence of downtrend in Greek.

2.2. The correlation of song melody and speech tone

In many tone languages, notably in Africa and Asia, the correlation of song melody with speech tone is so high that it can generally be expressed in terms of rules. This characteristic of the vocal music of tone languages is obviously related to the important functional role played by pitch in those languages. For example, in the Nigerian tone language Igbo, a song might contain the following line: *Akwa adigh n'elu igwe*. This line has a number of different meanings, depending on the tones of both syllables of the first and last word. If a song composer arbitrarily composed a melody for this line, he would be arbitrarily assigning one of the following meanings to the line: 'There is no sorrow in heaven,' 'There are no tears on the bicycle,' 'There are no eggs in the sky,' 'There is no clothing among the crowd,' 'There is no egg on the iron,' etc. In order for the composer to convey the correct meaning of the text, he must compose a melody that reflects the speech tones of the two words in question.[58] Since nearly all Igbo music is based on song, linguistic tone (and intonation) have a formative influence on the melody of Igbo music. However, it is not the case that the melody of song in tone languages is faithful to the linguistic tones only when ambiguity would otherwise arise. The correlation of speech and song melody is an overall rule and so more probably related to the general high functional yield of pitch differences in these languages. In fact, because of the inbuilt redundancy of language, Chinese without tones, as often spoken by foreigners, is fairly intelligible provided that the pronunciation and syntax are

[58] Ekwueme (above, note 56).

otherwise free of distorting errors.[59] Greek likewise has a significant number of minimal pairs of words distinguished only by an accentual difference, involving both lexical and inflectional morphemes; and, apart from its functional yield, the general importance of pitch in a pitch accent language is greater than in a stress language, since in stress languages the word accent can be realized by features other than pitch. For the avoidance of speech-song tonal mismatches in a pitch accent language, a passage may be cited from Zeami (1363–1443), the foremost writer and theoretician of the Japanese sung *noh* theatre, which probably indicates that such mismatches are undesirable in major lexical categories.[60]

In general, it is much more important for song melody to preserve the direction of pitch movement than it is for it to maintain the true pitch of an utterance or to replicate the pitch intervals precisely. Although we shall cite some data quantifying average intervals in semitones, the object of most of our analysis will be to establish relational or directional properties, that is "same," "higher," "lower," and "level," "rising," "falling." In the Hausa tonal sequence High Low High, the Low tone can sometimes be realized by the same musical note as the preceding High; this is not a mismatch but reflects a feature of phrase intonation in fluent speech.[61] This observation about Hausa is important in that it indicates that the tonal relations reflected in the music are those of the surface phonetic output, after the lexical tones have been adjusted by factors like sandhi and intonation. It follows that, conversely, we are in principle justified to exploit the evidence of Greek music to reconstruct the surface tonal relations of Greek speech.

2.3. The evidence of the Delphic hymns

The Delphic hymns show the strictest rules of correspondence between linguistic pitch accent and musical setting of all the remains of Greek vocal music, and are, therefore, the best potential source of data against which to test for the existence in Greek of the typological regularities governing the production of tone discussed in section 1.2 and from which to seek to answer the questions raised in section 2.1. Previous understanding of those rules may be summarized as follows:[62]

> 1. The accented syllable (whether acute, circumflex or grave) is not set lower than any other syllable of the word.
> Specifically by accent type:
> 2. The acute accent in trisyllables and longer words is preceded by a rise and followed by a fall in pitch.

59 Y. R. Chao, "Tone, Intonation, Singsong, Chanting, Recitative, Tonal Composition, and Atonal Composition in Chinese," *For Roman Jakobson*, ed. M. Halle, H. G. Lunt, H. McLean and C. H. van Schooneveld (The Hague 1956) 52.

60 A. Omote and S. Kato, *Zeami, Zenchiku, Nihon shiso taikei* (Tokyo 1978) 24.

61 W. R. Leben, "On the Correspondence between Linguistic Tone and Musical Melody," *African Linguistics*, ed. D. L. Goyvaerts (Amsterdam 1985) 335.

62 S. Eitrem, L. Amundsen, and R. P. Winnington-Ingram, "Fragments of Unknown Greek Tragic Texts with Musical Notation, II: The Music," by R. P. Winnington-Ingram, *SO* 31 (1955) 28–87. E. Pöhlmann, *Denkmäler altgriechischer Musik* (Nürnberg 1970).

3. The circumflex accent is most frequently set to a melism, the second note of which is generally lower, and not higher, than the first.
4. A grave accent is not set lower than any other syllable of the word; moreover, it cannot be higher than the next following acute or circumflex accent and often is not higher than following unaccented syllables.

The strictness with which these rules are observed establishes for the Delphic hymns a level of respect for pitch patterns and movements in Greek speech that is likely to hold for the pitch patterns of other linguistic structures and units in addition to those involved in the rules above. The questions of section 2.1 are empirical ones, designed on the basis of the typological investigation of sections 1.2 and 1.3 to lead to answers in terms of regular patterns and processes of the tones of Greek speech. Therefore if we can observe a regularity governing the musical settings of the linguistic units and structures involved in one of our questions, and if we can show that this regularity is statistically significant, and not merely a coincidental occurrence, then we may safely assume that the regularity of the musical setting reflects the regularity of speech. Conversely, any statistically significant correlation between music and speech revealed by more detailed analysis of the hymns may be tested against the typological generalizations of sections 1.2 and 1.3 to judge whether it is linguistically natural, and therefore another prima facie pattern in Greek speech, or a musical artificiality. Thus the triple controls of typological naturalness, musical respect for the surface phonetic patterns of pitch in Greek speech, and statistical testing will permit us to reconstruct the tone relations and movements of words and utterances of ancient Greek in far more detail than has hitherto been possible.

The Delphic hymns are composed in the diatonic and chromatic genera,[63] so that intervallic measurements may be given in tones and semitones. We have ignored theoretical, small differences between intervals in the tetrachord such as tones of 9/8 and 8/7 for Archytas' diatonic genus. Examples are cited in Pöhlmann's transcription of the vocalic and instrumental notations into staff representation. It should be remembered that measurement in semitones constitutes a logarithmic transformation (with base of $\sqrt[12]{2}$ in a tempered scale) of linear measurement in Hertz; i.e. the interval, D, in semitones between two pitches of f_1 and f_2 frequency is $D=12\log_2(f_1/f_2)$.

2.3.1. Intrinsic and segmentally conditioned differences of pitch

There are two methods by which we can test for any tendency in the Delphic hymns for the musical setting to reflect the effects of vowel height and stop voicing on pitch discussed in section 1.2 above. The first is to test for any effect on the interval between the pitch peak of a nonfinal accented syllable and the pitch valley of the final (unaccented) syllable of the same word. This method is chosen for the test of the effect of vowel height. If there were any tendency for the setting to reflect the differences in fundamental frequency associated with differences in vowel height, then, on the average, the interval between the accentual peak on a high vowel and the valley on a final low vowel should be greater

[63] Pöhlmann (above, note 62, hereafter P.) 67, 76. Jacques Chailley, *La musique grecque antique* (Paris 1979) 154–166.

than the corresponding interval when the final vowel was mid, and the latter should be greater than when the final vowel was high, and similarly through all combinations of vowel height to a minimum when the accentual peak was on a low vowel and the final valley on a high vowel. An initial search for examples to concretize the foregoing deduction certainly does not appear to support it; for a high vowel - low vowel interval one may cite Κυνθίαν P.20.13 set to ∪ [(f^1 e^1), for a high vowel - mid vowel interval σύρων P.20.25 set to Ↄ ∪ (b b^b), for a high vowel - high vowel interval Δελφίσιν P.19.6 set to ΘI̲Θ (e^{b1} d^1e^{b1}), and for a low vowel - high vowel interval οὐράνιος P.20.8 [< ‾ (e^1 d^1). For a statistical test it is sufficient to classify vowels and diphthongs simply as high, mid, and low, ignoring the difference between high-mid and low-mid. The mean intervals as just defined are calculated for each of the resulting nine combinations of vowel height in the hymn by Limenius (P. 20). Only words bearing the acute accent are considered, but the circumflex behaves similarly. The results are given in Table 1.

ĹL	ĹM	ĹH	ḾL	ḾM	ḾH	H́L	H́M	H́H
0.93	1.19	1.00	1.39	1.64	1.56	1.57	1.86	2.67

Table 1: Mean intervals between accentual peak and valley of the unaccented final syllable in words bearing the acute in P.20 classified according to vowel height combinations.

The results do not conform to the deductions. An analysis of variance, presented in Table 2, confirms that the differences among the mean intervals are merely random.

Source of Variation	Sums of Squares	*df*	Mean Squares	$F = MS_b / MS_{\underline{w}}$
SS	203.24	76	—	—
SS_b	9.33	8	1.17	—
SS_w	193.92	68	2.85	0.4
			$p >>> .05$	

Table 2: Analysis of variance of data underlying Table 1.

Consequences for reconstruction, 1: the test results of Tables 1 and 2 indicate that the intrinsic effect of vowel height on pitch in ancient Greek was not of sufficient perceptual salience to be reflected in musical settings.

The second method is to calculate the average pitches of syllables of different types. Since the Greek notation does not provide absolute pitches (as implied by the staff transcription), the pitch measurement must be made in terms of intervals (above or below) an arbitrary reference. This method was used to test for any tendency for the musical settings to reflect contextual difference in fundamental frequency associated with stop voicing. If there were any such tendency, we should expect that, on the average, the pitch of a syllable with a voiced consonant onset such as the -δύ- of ἀδύθρους P.19.15, set to Γ (f^1), would stand lower in relation to the reference pitch than a syllable with a voiceless stop onset, such as the -θύ- of θύγατρες P.19.2, set to I (d^1). Since accented syllables have a higher mean pitch than unaccented ones, the two classes must be treated separately. Accented syllables were limited to the acute, and their mean calculated for P.19 and P.20, unaccented syllables were taken from P.19 only. The arbitrary reference was chosen as *M* (c^1). The results are presented in Table 3, where *TV* represents a syllable with a voiceless (aspirated or unaspirated) stop onset and *DV* one with a voiced stop onset.[64]

	Acute	No Accent
TV	m = 1.86	m = 1.03
	s = 1.58	s = 1.47
DV	m = 2.31	m = 1.45
	s = 1.69	s = 1.80

Table 3: Mean pitch relative to an arbitrary reference of accented and unaccented syllables classified according to stop voicing of the onset.

For both accented and unaccented syllables the mean intervals above the reference pitch are actually greater for syllables with voiced onsets, although the differences are not statistically significant. To control for the possibility that collapsing over differences of vowel height might have dampened the observed differences, that is that there might be an interaction effect between stop voicing and vowel height of the following vowel in determining pitch, the data for unaccented syllables were crossclassified according to vowel height and stop voicing. (Crossclassification of the data for accented syllables reduces the sample sizes so severely that the test would lack adequate power to detect significant differences.) The greatest difference between the means was found for syllables with low vowels (*L*): the mean for *TL* as 1.25 and that for *DL* 1.88. Again the difference was not statistically significant: $t = 0.92$, $df = 20$, $p > .05$.[65]

> *Consequences for reconstruction, 2: the test results of Table 3 and further controlled testing indicate that the contextual effect of stop voicing on pitch in ancient Greek was not of sufficient perceptual salience to be reflected in musical settings.*

The effects of intrinsic fundamental frequency are reduced in singing as compared to speech; Swedish choir singers compensated fairly successfully for intrinsic fundamental frequency differences by auditory monitoring of their performance.[66] However, the intrinsic fundamental frequency effect that remains in singing is still well above the threshold of detection; in unaccompanied solo singing, listeners—including the singers themselves—seem to compensate

64 m indicates the sample mean, and s the sample standard deviation.
65 df means degrees of freedom and is 1 less than the sum of the number of observations in each sample. p indicates the level of significance of the observed difference measured by t and means the probability of a t as large or larger than that observed occurring if in fact there were no difference between the sample means.
66 S. Ternström, J. Sundberg and A. Colldén, "Articulatory F_0 Perturbations and Auditory Feedback," *Journal of Speech and Hearing Research* 31 (1988) 187.

perceptually for intrinsic fundamental frequency differences.[67] It is not clear from a purely theoretical point of view if, or how, the setting of the Delphic hymns would be sensitive to any such performance tendencies. So the results of our tests for musical reflexes of inherent and contextual segmental effects on pitch, while negative, are nevertheless of considerable value. First of all, given the anatomical/physiological basis and empirical universality of the effects of vowel height and stop voicing discussed in section 1.2, those effects must also have been operative in ancient Greek. Consequently the negative test results indicate that the strength of those effects was not so great that the musical settings would be constrained to reflect them. Such a conclusion fits well with the further typological evidence that these intrinsic and contextual effects on pitch are inversely proportional to the functional value of pitch in a language; since this was relatively high in Greek, the intrinsic and contextual effects would have been proportionally lower. Secondly, it is methodologically important that the musical settings do not reflect intrinsic and contextual segmental effects; they may be ignored in all the following tests, thereby greatly simplifying the design of those tests and also increasing their power to detect real effects on tone movement by permitting us to operate with larger sample sizes.

2.3.2. The grave accent

It has long been recognized that the musical documents treat the grave accent as a lowered High tone, not as an unaccented syllable. Statistical analysis definitely confirms this effect in the Delphic hymns. Since, as demonstrated in section 2.3.6, the pitch excursion to the grave is strongly influenced by its location in catathesis domains, and these domains correlate very strongly with syntactic units, not all grave accents may legitimately be treated together for analysis. Since catathesis does not apply before the accentual fall of the initial word of a clause or major phrase, adequate control may be obtained by excluding the grave accents in these positions and treating only clause or phrase internal graves. (The grave, of course, does not occur clause finally.) Now if the grave were a lowered High tone, it would follow that there should be a positive mean rise to it, but that this mean rise should be significantly less than the mean rise to the acute. In order to achieve comparability in the measurements of the respective mean rises and to control for the fact that syllables following the accentual peak within a word are lower than the syllables preceding that peak (see section 2.3.3), it is necessary to limit the analysis to polysyllables and to exclude the rise to accents across word boundaries. Thus the rise to monosyllables bearing the grave, such as δὲ, and the rise to word initial acutes are excluded. Consequently our procedure is to calculate the mean rise to the grave in polysyllables such as λωτὸς P.19.14, set to OOM (b $b\overset{\frown}{c^1}$), ἐσμὸς P.19.17, set to Γ Γ (f^1 f^1), κλυτὰν P.20.14, set to < ⊏ (d^1 e^1), and ἐπὶ P.20.14, set to ⊏ ⊔ (e^1 f^1), and the mean rise to the acute in words such as 'Ατθίδ' P.20.14, set to ⊏ ϟ (e^1 a^1) and ἐκείνας P.20.19, set to K < ⊻ (b d^1 c^1) .Proper names and nonlexical words, as well as lexical words, bearing the grave or acute accents are included. The grave cases are taken from P.19 and P.20; for the acute P.20 provides an

[67] N. R. Petersen, "The role of Intrinsic Fundamental Frequency in the Perception of Singing," *WPGLP Lund University 34* (1988) 99.

ample data set. Of course, to maintain comparability, only clause and major phrase internal acutes are admitted. The results are presented in Table 4, along with Student's t-test of the differences between the mean rise to the grave, m_g, and the mean rise to the acute, m_a.

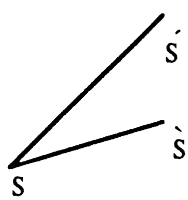
To Grave	To Acute
$m_g = 0.31$	$m_a = 0.92$
$s_g = 0.53$	$s_a = 1.43$

$$t = 2.01,\ df = 68\ m_g < m_a$$
$$p < .025$$

Table 4: Comparison of the mean rise to the grave with the mean rise to the acute.

On the average, the rise to the grave is about a third of a tone. This mean rise is significantly greater than zero ($t = 4.89$, $df = 23$), so that we must conclude that the grave has a higher pitch than the syllable before it in the word. In comparison, the mean rise to the acute is nearly a tone, and, as the value $t = 2.01$ indicates, it is significantly greater than the rise to the grave.

Consequences for reconstruction, 3: the test results of Table 4 indicate that the grave accent was the pitch peak of the word, but that the rise to it was substantially less than the rise to the acute. This reconstruction can be represented schematically as follows:



The status of the grave as a lowered High tone is nicely illustrated by pairs of successive words in which the initial syllable of the second word bears the acute or circumflex.

P.19.14.

P.19.15

P.20.39

The status of the grave as a lowered High tone may also be established by comparing its pitch to that of the nongrave accent of an immediately following word. In order not to introduce the interacting factors discussed in sections 2.3.6 and 2.3.7 below, proper names and nonlexical words are excluded. Accents on the first lexical word of a clause or participial phrase are also excluded. The mean rise from the grave to the following nongrave accent, ${}_{g}A$, is given in Table 5 along with the t-test of the hypothesis that this rise is greater than zero.

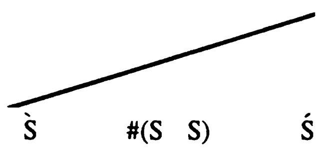
$$-\grave{S}\#(\ldots)\acute{S}S(\ldots)\#$$
$${}_{g}A = 1.22$$
$$s = 0.57$$

$${}_{g}A > 0 : t = 6.12,\ df = 8$$
$$p < .0025$$

Table 5: The mean rise from grave to an immediately following nongrave accent is statistically significant.

Even though there are only 9 cases preserved which meet the criteria defined for the test, the mean rise of a little more than a tone is statistically significant. The lowered status of the grave becomes all the more striking when it is realized that there is a mean *fall* in pitch from one nongrave accent to the next nongrave within clauses and major phrases (see section 2.3.5).

Consequences for reconstruction, 4: the test results of Table 5 indicate that the grave was subordinate in pitch to a following full (acute or circumflex) accent. This result can be represented schematically as follows:



The magnitude of the excursion to the grave varies according to the number of morae over which the rise is distributed and the status of the grave word as proclitic or lexical. Pitches were preserved for seven proclitic grave words: ἐπὶ (3x), ἀνὰ (2x), and ἠδὲ (2x). There are no data for word internal rises to the grave for nonlexical words which are not also proclitics. Since the pitches of longer words bearing the grave such as ἑλικτὰν P.19.23 and θυρσοπλὴξ P.20.20 are only poorly attested, lexical grave words must be dichotomized into 1) iamb- and trochee-shapes, e.g. λαχὼν P.19.17 and ἑσμὸς P.19.17 (both with no rise) and 2) spondee-shapes, e.g. ᾠδὰν P.19.15, and longer words. Even when the grave syllable consists of a short vowel followed by a voiceless obstruent, e.g. λωτὸς P.19.14, it may be set to a rising melism, just like long vowel grave syllables such as -ὰν in ᾠδὰν above. Accordingly, the peak of the grave has been taken to be located on the final mora in all cases. There are no data for pyrrhic-shaped lexical words in clause and phrase medial positions. Table 6 presents the mean total rise from the beginning of grave words for the three classes distinguished. Below the table are given the results of the Jonckheere-Terpstra test[68] of the hypothesis that the rise to grave increases from proclitics to lexicals with two pregrave morae, and to lexicals with three or more pregrave morae: $MG(p, x \leq 2) \leq MG(l, 2) \leq MG(l, x \geq 3)$, with at least one strict inequality.

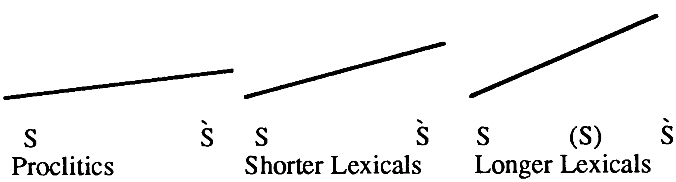
Grave class: pregrave morae	Mean total rise
$MG(p,x\leq 2)$	0.07
$MG(l,2)$	0.21
$MG(l,x\geq 3)$	0.63

$MG(p,x \leq 2) \leq MG(l,2) \leq MG(l,x \geq 3)$:
$J = 116,\ z = 1.61$
$p \approx .054$

Table 6: The rise of the grave increases with the number of pregrave morae and status as lexical word.

The rise to the grave triples as one moves from proclitics (0.07) to disyllabic lexicals (0.21) to trisyllabic and longer lexical words (0.63 tones). The value of the z-approximation to the distribution of the test statistic J shows that there is just slightly more than a one in 20 chance that a J this large or larger would arise at random if the means actually did not differ.

Consequences for reconstruction, 5: the test results of Table 6 indicate that the magnitude of the excursion to the grave accent is a function of two variables: 1) the rise to the grave is greater in lexical words than in proclitics, and 2) the rise is greater the larger the number of morae it covers. This reconstruction may be represented schematically as follows:



Although in the medial positions studied proclitics have almost no rise to the grave, in sentence initial position there is a rise of an octave on the proclitic Ἀλλὰ P.20.26, as large a rise as any to the acute or circumflex in initial position. This fact suggests that disyllabic proclitics are not phonologically unaccented like enclitics, but rather have an underlying accent which is substantially reduced in most circumstances, but which can emerge as an excursion under

[68] See W. W. Daniel, *Applied Nonparametric Statistics* (Boston 1990) 234–38.

special circumstances. The correlation of the magnitude of the excursion to acute and circumflex accents with lexical status and number of syllables is discussed in section 2.3.3.

2.3.3. Pre- and postaccentual syllables and the Mid-High-Low contour of medially accented polysyllables

There is ample evidence from the Delphic hymns to confirm Dionysius' implicit claim that medially accented Greek polysyllables had Mid tones and to show that in fact they followed a Mid-High-Low pitch contour, not a Low-High-Low contour. There are a number of settings of polysyllables which clearly exemplify this Mid-High-Low pattern, e.g.

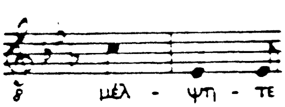
P.19.15

P.19.18

P.20.23

The hypothesis of such a phonetic Mid-High-Low contour certainly would explain Winnington-Ingram's observation[69] that "the tendency to fall from the accented syllable is distinctly stronger in these hymns than the tendency to rise to it." More generally, it is true that preaccentual syllables had a higher pitch relative to the accentual peak of the word than postaccentual syllables, so that pitch fall to the first syllable after an initial accent was greater, on the average, than pitch rise to the circumflex on final syllables, as comparison of the settings of μέλψητε with that of ἀκρονιφῆ in the following example makes clear.

P.19.4



[69] Winnington-Ingram (above, note 62) 66.

P.19.19

We shall test the hypothesis of a Mid-High-Low contour first at the nominal level of its implications, i.e. in terms of the proportions of unaccented plus accented and accented plus unaccented syllables within the word which are set, respectively, to rising and falling intervals, regardless of the size of those intervals. If preaccentual syllables were linguistically closer in pitch to the accentual peak than postaccentual syllables, it would follow that there would be less of a mismatch between the phonetic pitch contour and the musical setting when preaccentual syllables were set to the same note as the accentual peak, such as βαθύδενδρον P.19.1 with βα- and -θύ- both at I (d^1) (but -δεν- at M [c^1]), or χρυσέα P.19.15 with χρυ- and -σέ- at Γ (f^1) (but -α at Λ [d^b]), or οὐράνιος P.20.8 with οὐ- and -ρά- at ⊏ (e^1) (but -νι- at < [d^1]), than when the postaccentual syllable was set to the same note as the accentual peak, such as αἰόλον P.19.23 with -ό- and -λον at ⍏ (a^{b1}), πόλει P.20.21 at ⊔ (f^1), or ναέτας P.20.36 with -έ- and -τας at V (e^{b1}) (but with να- at < [d^1]). Consequently, it would be expected that the proportion of preaccentual syllables set to the same note as the following accentual peak would be greater than the proportion of postaccentual syllables set to the same note as the preceding accentual peak. Similarly, reversal of the phonetic pitch relations, such that the preaccentual syllable is actually set higher than the accentual peak should be more common than reversal with postaccentual syllables. It is immediately striking that there is only one case in the two hymns of a reversal with the preaccentual syllable, φερόπλοιο P.19.10 with φε- at Λ (d^{b1}) and -ό- at M (c^1), but no case of the corresponding reversal with the postaccentual syllable.[70] To test this nominal level implication of the Mid-High-Low hypothesis, we collected all the cases in which the settings of the relevant syllables were preserved for trisyllabic and longer words bearing the acute accent (including proper names) and calculated the proportions of the immediately preacute syllables set higher than or equal to the peak of the acute and compared the result to the corresponding calculation for the immediately postacute syllables. The results are given in Table 7 separately for each hymn.

	P.19		P.20	
	$\acute{S} > S$	$\acute{S} \leq S$	$\acute{S} > S$	$\acute{S} \leq S$
#(...)$S\acute{S}$...)#	62.75%	37.25%	63.51%	36.49%
#(...)$\acute{S}S$(...)#	87.04%	12.96%	87.65%	12.35%
	odds ratio =	0.25	odds ratio =	0.24

70 There is one case of a second postaccentual syllable set higher than the accentual peak δικόρυφον P.20.2 with -κό- at ⊏ (e1) and -φον- at ⊔ (f1), but the immediately postpeak syllable shows a fall: -ρυ- at < (d1). It may not be coincidental that φερόπλοιο and δικόρυφον are compound words with recessive accentuation.

chi-square = 8.31 chi-square = 12.40

Table 7: Postacute fall is more regular than preacute rise.

The results show that there is hardly any difference between the two hymns. The values of the odds ratios, 0.25 and 0.24 respectively, mean that the odds for a preacute syllable to be set lower than the acute (approximately 5:3) are only about a quarter of the corresponding odds for postacute syllables (approximately 7:1). The values of the chi-squares, 8.31 and 12.40 respectively, mean that these differences in the treatment of pre-and postacute syllables vis-à-vis the peak of the acute are statistically significant and cannot be attributed to chance.

The Mid-High-Low hypothesis obviously implies that the mean absolute interval of rise from an immediately preaccentual syllable to the accentual peak is significantly less than the mean absolute fall from the peak to the immediately following syllable. Now the simple fact just established that the proportion of immediately postaccentual syllables set lower than the accentual peak is greater than the proportion of immediately preaccentual syllable set lower would by itself cause the mean rise to be less than the mean fall, even if the cases involving only rises and fall were of identical intervals. A test, therefore, must be conducted only on those cases which, in fact, show rises and falls, with the instances of equal settings (and the one case of a reversal) excluded. The words studied continue to be trisyllabic and longer ones bearing the acute on a nonfinal syllable. The results are given in Table 8, where m_r indicates the mean rise and m_f the mean fall (and these are both reported as positive).

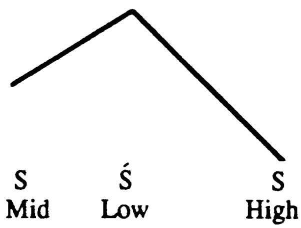
#(...)$S\acute{S}$...)#	#(...)$\acute{S}S$(...)#
$m_r = 0.80$	$m_f = 1.33$
$s_r = 0.21$	$s_f = 1.12$

$m_r < m_f$: $t = 2.03$, $df = 65$
$p < .025$

Table 8: Mean rise to the acute less than mean fall from the acute.

The average pitch fall from the acute (1.33 tones) is greater than the average rise to the acute (0.80 tones) by a little more than a semitone. The value t = 2.03 with 65 degrees of freedom (i.e. a total sample size of 67), means that this difference of approximately a semitone is statistically significant. As the value $p < .025$ indicates, there is less than two and a half chances in a hundred that a difference greater than or equal to that observed could have arisen at random.

Consequences for reconstruction, 6: the test results of Tables 7 and 8 indicate that the magnitudes of the excursions to and from the accentual peak are not equal: the fall from the peak is considerably greater than the rise to it. Prepeak, peak, and postpeak syllables thus formed a Mid-High-Low contour. This reconstruction may be represented schematically as follows:



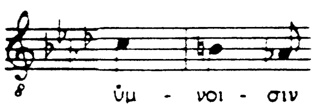
We may extend our exploration of the pitch contour of polysyllables further from the accent in both directions. Pitch tends to rise from the second to the first syllable before the accent, as exemplified by ἀκρονιφῆ P.19.19 above and

P.20.20–21

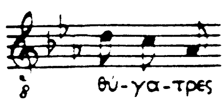
P.19.13–14

Conversely, pitch tends to fall from the first to the second postaccentual syllable, as exemplified by

P.19.16



P.19.2



As would be expected from the parallels cited in section 1.2, the magnitude of accentual excursions to and from the acute and circumflex varies according to the lexical status and the number of syllables covered. We demonstrate this effect first for the peak to valley excursion. To control for other factors which can influence the magnitude of excursions, such as emphasis, focus, terminal fall and the like, we exclude proper names, words which stand in initial and final positions in clauses and major phrases, words which seem, prima facie, to be especially focused, and all words which have a secondary rise in pitch after the first postpeak fall, since the last are generally associated with special contextual factors involving emphasis (see sections 2.3.4 and 2.3.7). To control for word length we crossclassify paroxytones and proparoxytones according to the presence or absence of an unaccented syllable before the acute. There are so few words with two or more preacute syllables that they must be ignored. Similarly, there are too few circumflex words to permit this crossclassification. The results are presented in Table 9, where the mean total peak to valley interval is denoted as a function of lexical status (n = nonlexical, l = lexical) and the number (1 or 2) of the postpeak syllables. The means for words with a preacute syllable are distinguished by prefixing an M (for Mid tone) to the symbols PV (: :).

#Ś. . .	#SŚ . . .
$PV(n,1) = 0.70$	$MPV(n,1)$: ἐκείνας (1x) = 1
$s = 0.84$	--------
$PV(l, 1) = 0.92$	$MPV(l, 1) = 1.18$
$s = 0.69$	$s = 0.82$
$PV(l, 2) = 2.20$	$MPV(l, 2) = 1.58$
$s = 0.98$	$s = 1.28$

$PV(n,1) \leq PV(l,1) \leq PV(l,2)$:
$J = 377.5,\ z = 3.50,\ p < .001$

Table 9: Correlation of peak to valley interval with lexical status and number of syllables.

In each column the peak to valley interval increases from nonlexical to lexical words (although there is only the single data point, ἐκείνας, for nonlexicals with a preacute syllable) and from paroxytone to proparoxytone lexicals. Below the #Ś . . . column for initial acute accents are given the results of the Jonckheere-Terpstra[71] test for the hypothesis that the peak to valley intervals are ordered as $PV(n, 1) \leq PV(l, 1) \leq PV(l, 2)$, with at least one strict inequality. As the value 3.50 of the z-approximation indicates, the increase over the three classes is statistically significant with only one chance in a thousand that the observed trend could arise at random. The fact that there is a fairly substantial decrease across the columns for $PV(l, 2)$ to $MPV(l, 2)$, but a small increase from $PV(l, 1)$ to $MPV(l, 1)$ indicates that there is no meaningful correlation between peak to valley interval and the presence of a rise to the peak. Maintaining the same controls as above, but averaging over paroxytones, proparoxytones, perispomena, and properispomena, we find that the mean rise over one syllable to the peak is $MP(l, 1) = 0.70$ and the mean rise over two or more is $MP(l, x \geq 2) = 1.00$. Although the difference cannot be demonstrated to be statistically significant in the small data set available, it is in the same direction as the peak to valley increase, and we may conclude that rise to the peak is also an increasing function of the number of syllables which it covers.

Consequences for reconstruction, 7: the test results of Table 9 and additional data indicate that the magnitude of the excursions to and from the peak of a full accent is a function of two variables: 1) both the rise to and the fall from the peak are greater in lexical words than in nonlexicals, and 2) both the rise and the fall increase the more morae they cover. A schematic representation of this reconstruction is given below in Figure 5, following the discussion of variation of peak and valley pitch levels.

For unemphatic lexical words, variation in the magnitude of accentual excursions results almost entirely from variation in the pitch of word initial Mid

[71] Daniel (above, note 68) 234–238.

tones and word final Low tones, rather than from variation in the pitch of the accentual peak. In fact, in the sample of unemphatic, lexical proparoxytones in medial position, a weak, negative correlation ($r = -0.33$) is observed between the total interval of fall, HL_2, and the height of the peak, H, above a reference pitch. This correlation, however, is not statistically significant, so that we may assume that there is no relation between the pitch of accentual peaks and the total peak to valley fall in the absence of factors which might boost pitch. There is a statistically significant, although weak, positive correlation ($r = +0.33$) between the pitch of H and the total interval of rise from the beginning of the word to H among unemphatic lexicals in medial position which have at least one prepeak syllable. Since this correlation is weak, however, the major portion of the variation in the interval of rise to the peak is produced by variation in the pitch of the initial Mid tone, with less dependence on the pitch of H. The fact that the peak to valley excursion in nonlexical paroxytones is smaller than in lexical paroxytones of the same length is in substantial part a result of the process that subordinates the pitch of nonlexical acutes and circumflexes to the peaks of following lexical acutes and circumflexes (see section 2.3.7.2): nonlexical peak to valley excursions are smaller than lexical ones to some extent because nonlexical peaks are never higher than lexical peaks. It seems, therefore, that when variables that influence the level of all the pitches of a word, Mid, High, and Low, such as lexicality, catathesis, emphasis, focus, etc. (see sections 2.3.5–2.3.7) are factored out, the accentual peaks of words are relatively independent of word length. It is the final Low and initial Mid tones that fall as additional syllables are added on their respective sides of the accentual peak, although the peak shows some tendency to be higher with increasing intervals of rise to it. The peaks represent a fairly stable phonetic target, whereas the valleys are variable, being contextually determined. This reconstruction, along with the small correlation of peak level with prepeak morae, is represented schematically in Figure 5, where the length of the vertical lines indicates the magnitude of the rise to the peak, P, from one preaccentual syllable, *M(1)*, over two, *M(2)*, or three, *M(3)*, and the fall from the peak to the word's pitch valley over one, *V(1)*, two, *V(2)*, or three, *V(3)* postaccentual syllables:

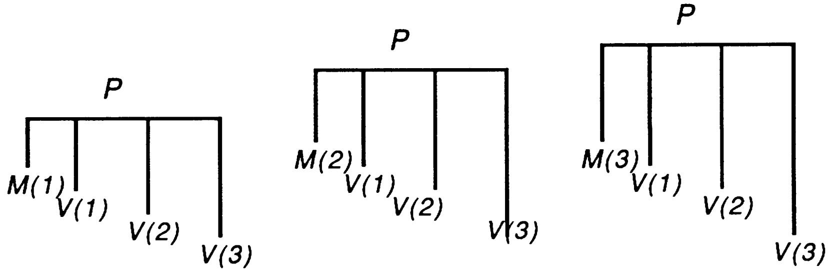


Figure 5: Intervals of rise and fall increase with morae covered; peaks are relatively stable.

When the peak to valley excursion covers two syllables, the pitch trajectory of the fall does not lie along a single straight line connecting the H of the peak, the low of the first postpeak syllable, L_1, and the low of the second postpeak syllable, L_2, as in Figure 6:

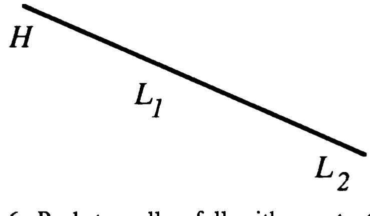


Figure 6: Peak to valley fall with constant slope over two syllables.

Neither does the trajectory consist of a steep fall from H to L_1 and a flat line to L_2, as in Figure 7:

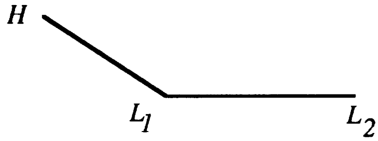


Figure 7: Peak to valley with a flat trajectory from L_1 to L_2.

Rather, the fall from H to L_1 is greater than the fall from L_1 to L_2, so that the line HL_1 has a much steeper slope than the line L_1L_2, as represented in Figure 8:

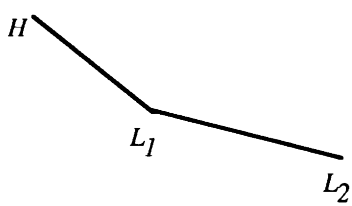


Figure 8: Schematic representation of the actual peak to valley trajectory over two syllables in Greek.

Table 10 gives the means HL_1 and L_1L_2 for lexical proparoxytones of all lengths. The same controls on position and emphasis are maintained; note in particular that secondary rises from L_1 to L_2 are excluded, so that the means reflect the normal pattern, $H > L_1 > L_2$, and L_1L_2 is not artificially decreased.

	#. . . $\acute{S}SS$#
$HL_1 = 1.29$	$L_1L_2 = 0.50$
$s = 1.16$	$s = 0.50$

$HL_1 > L_1L_2$: $t = 2.33$, $df = 32$

$p < .025$

Table 10: The interval from the peak to the low of the first following syllable is significantly greater than the interval from that low to the low of the final syllable.

The interval of fall from H to L_1 is over two and a half times as great as the interval from L_1 to L_2, and the difference is statistically significant. The same pattern holds for the few perispomena and properispomena whose pitch relations are fully preserved. The same pattern $HL_1 > L_1L_2$ also holds for lexical proparoxytones (not proper names and not having secondary rises) which stand at the beginnings and ends of clauses or major phrases. Table 11 presents the data for the means in initial position, $[HL_1$, $[L_1L_2$ and final position $HL_1]$ and $L_1L_2]$.

#. . . $\acute{S}SS$# in Initial and Final Positions

$[HL_1 = 1.30$	$HL_1] = 2.00$
$s = 1.44$	$s = 1.98$
$[L_1L_2 = 0.60$	$L_1L_2] = 0.13$
$s = 0.89$	$s = 0.23$

Table 11: The interval from the peak to the Low of the first syllable remains greater than the interval from that Low to the Low of the final syllable in initial and final positions as well as in medial positions in clauses and major phrases.

The fact that, despite the compressive effects of catathesis, HL_1 is greater in final position than in initial or medial position reflects terminal fall. The fact that L_1L_2 is smaller in final position than in either initial or medial position indicates that terminal fall was concentrated in HL_1, leaving little range for further fall over L_1L_2.

The interval of fall from H to L_1 in all positions, initial, medial, and final, is over twice as great as the interval from L_1 to L_2. Pitch does not fall at a constant rate from peak to valley, but there is a discrete change in the rate of fall after L_1. Not only is the immediate postpeak fall in proparoxytones (and properispomena) the major component of the total peak to valley excursion, it is statistically indistinguishable from the mean peak to valley interval in lexical paroxytones of all lengths: $PV\ (l, 1) = 1.10$, $s = 0.73$. This relative constancy of the immediate postpeak fall along with its greater magnitude than the L_1L_2 fall suggests that the HL_1 segment is the most salient cue of a full accent. The much smaller interval of the L_1L_2 fall segment and its nearly flat average slope in final position ($L_1L_2] = 0.13$) indicate that the L_1L_2 segment may in fact not be a necessary part of signalling the accent at all, but may be subject to contextually motivated reduction. This inference is important for the analysis of the phenomenon of secondary rise discussed in section 2.3.4.

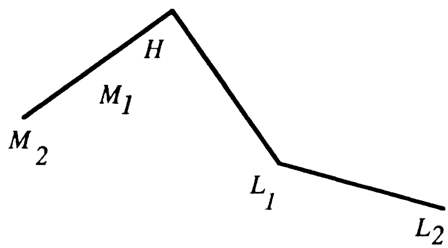
Data for the trajectory of the rise to the accentual peak covering two or more syllables are quite restricted. Table 12 gives the mean rise from the third to the second preaccentual syllable, M_3M_2, the second to the first, M_2M_1, and from the first to the peak, M_1H. The same controls as in Table 10 are maintained, but words with the circumflex are now included.

$M_3M_2 = 0.13$	$s = 0.25$
$M_2M_1 = 0.59$	$s = 0.49$
$M_1H = 0.36$	$s = 0.32$

Table 12: Data on the mean rise, syllable by syllable, to the accentual peak.

The variation over the syllables in Table 12 is probably random and not indicative of any significant deviation from a basic straight line trajectory.

Consequences for reconstruction, 8: the test results of tables 10, 11, and 12 indicate that pitch fall from the accentual peak consisted of two parts, a rapid, steep drop over the first postpeak mora and a slower, flatter fall over subsequent postpeak morae; pitch rise to the peak, on the other hand, was fairly steady. These reconstructions may be represented schematically as follows:



2.3.3.1. Interpretation of the Mid-High-Low contour

The hypothesis that medially accented Greek polysyllables had a Mid-High-Low pitch contour provides a phonetic motivation for one type of notational convention found in papyri whereby the syllable immediately preceding the acute and sometimes those further to the left are marked with the grave symbol, whereas syllables following the acute are unmarked, whether or not the acute itself is marked, e.g. φὶλὴσὶστέφανον, Πὰνελληνας.

The Mid-High-Low contour of Greek is fairly well supported by cross-linguistic data. In the pitch accent language Japanese, in tetrasyllables with accent on the second syllable, the initial syllable has a higher pitch than the final.[72] In the stress accent language Diegueño,[73] pretonic syllables have higher pitch than any post-tonic syllables.

Some of the movement producing a Mid-High-Low word contour results automatically from declination and from catathesis if the additional fall in pitch associated with catathesis is assumed to be located on successive High-Low movements in utterances. (A more detailed description of this process is given in section 2.3.5.) Further movement toward Mid-High-Low contours is encouraged in other languages by generalization of prepausal lowering to word final syllables and by progressive assimilation to a following High tone.

2.3.3.2. Mid tones and the grave accent

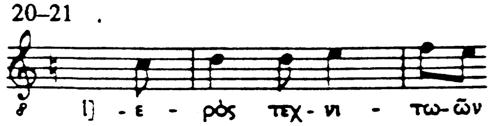
It is instructive to compare the settings of the Mid tones of preaccentual syllables with those of the grave accent. It can often be observed in the Delphic hymns that a grave syllable is set to the same pitch as that of an immediately following unaccented (word initial) syllable. Clear examples that also involve a rise to the grave are:

[72] Poser (above, note 2).
[73] M. Langdon, *A Grammar of Diegueño: Mesa Grande Dialect* (Berkeley, 1970).

P.19.24

P.20.14

P.20 20–21 .



In contrast (and as we would expect given the Mid-High-Low contour of medially accented polysyllables) it is much less common for unaccented word final syllables to be set to the same pitch as a following word initial unaccented syllable. In fact, in P.19 there is a mean rise of 0.85 tones from unaccented finals to unaccented initials within the same clause or major phrase (standard deviation = 1.35).[74] For P.19 and P.20 taken together, the data on the intervals from a grave accent to a following unaccented syllable, gS_1, in the same clause or major phrase are reported in Table 13.

$$\#(\ldots)\grave{S}\#S_1(\ldots)\acute{S}(\ldots)\#$$
$$_gS_1 = +0.24$$
$$s = 0.56$$

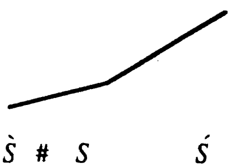
Table 13: Mean interval (rise) from grave to following unaccented word initial syllable.

We would, of course, expect from what has been established so far that the mean rise from the grave to a following unaccented syllable would be significantly less than the mean rise from a final unaccented syllable to a word initial unaccented syllable. The t-test for the difference between the respective means of 0.85 and 0.24 yields $t = 1.88$ with 47 degrees of freedom, so that there is less than one chance in twenty that a difference as great or greater than that observed would arise at random. Thus we have a further test which confirms that the grave syllable has a higher pitch than an unaccented final syllable. We do not have, however, any theoretical reason to expect that the grave would be either higher or lower than the Mid tone of a preaccentual syllable in words bearing the acute or circumflex. The fact that there is a statistically significant word internal rise to the grave could result from maintaining the normal preaccentual tonal relationship in the lower pitch range of grave words. Consequently, we must test the hypothesis that the grave simply has a different average pitch from the following word's initial unaccented Mid tones, not the more specific hypothesis that it was lower or, for that matter, that it was higher. When the t-test is applied to the difference between the mean of 0.24 and zero in Table 13, a

[74] This mean rise is significantly greater than zero ($t = 3.46$, $df = 29$, $p < .01$).

value $t = 1.84$ results, which with 17 degrees of freedom is not significant at the 0.5 confidence level. Consequently the data of the musical settings do not justify our rejecting the null hypothesis that the mean pitch of the grave is about the same as the pitch of a following unaccented syllable, especially those in words bearing the acute or circumflex. This interpretation accords with Sidney Allen's hypothesis of "a lowering of the final pitch to a level where it was no longer higher than the initial of the following word."[75]

Consequences for reconstruction, 9: tests applied to the data of Table 13 indicate that, within clauses or major phrases, the pitch of the grave was generally slightly lower than the pitch of a following unaccented syllable. This reconstruction may be represented schematically as follows:

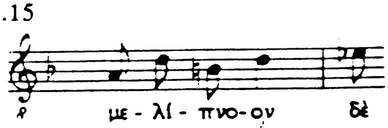


2.3.4. Secondary pitch rises and linguistic pitch sandhi

There are a number of cases in the Delphic hymns which are exceptions to the tendency observed in the preceding section for pitch to continue to fall after the first postpeak pitch, so that there is a rise in pitch after that first fall. Since pitch never rises and then falls back after the first postpeak fall, the maximum rise from the first postpeak fall is simply the interval from that pitch to the last pitch of the word. Examples of secondary rise are:

P.20.4

P.20.15

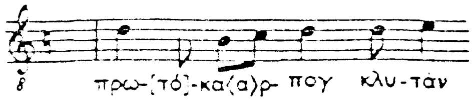


P.19.11

[75] W. Sidney Allen, *Accent and Rhythm* (Cambridge 1973) 246.

P.20.22

P.20.14



It is possible to discern the necessary condition which constrains secondary rise: with only one exception, δικόρυφον κλειτὺν P.20.2 set to < ⊔ < ⊔ <‿∪ < (d^1 e^1 d^1 f^1 d^1‿b^b d^1), secondary rise occurs only if the following word-initial syllable is set at least three semitones higher than the first postpeak pitch of the preceding word. Obviously, secondary rise can be observed only in properispomena, in proparoxytones, and in paroxytones with melisms set to their final (always heavy) syllable. In order not to bias the test of this hypothesized condition, it is necessary to exclude properispomena when their circumflexes are not set to (falling) melisms, since there is no postpeak fall preceding the final syllable, and any rise on the final would violate the strict regard for accentual pitch marking in the music. Paroxytones must be treated separately since there may be additional factors which constrain melisms in general. The strong association of secondary rise with the magnitude of the interval from the first postpeak fall to the following word initial syllable is demonstrated in Table 14; the subtable on the left reports the data for proparoxytones and properispomena, that on the right the data for paroxytones with and without rising melisms. D indicates the intervallic magnitude in question.

	#(...)$\acute{S}SS$# / #(...)$\hat{S}S$#		#(...)$\acute{S}\overline{S\#}$	
	D ≥ 1.5	D < 1.5	D ≥ 1.5	D < 1.5
Secondary rise:	92.31%	7.69%	100%	0%
No Secondary Rise:	16.67%	83.33%	7.50%	92.50%
	odds ratio = 60		odds ratio = ∞	
	chi-square = 21.71		p = .0003	

Table 14: Secondary rise is overwhelmingly associated with intervals greater than or equal to three semitones between the postpeak pitch and the following word initial syllable.

As the values of the chi-square and the exact probability by the hypergeometric distribution indicate, the association is highly significant. In the case of rising melisms on paroxytones, the necessary condition is exceptionless; in the case of properispomena and proparoxytones, the odds ratio shows that the odds are overwhelming for secondary rises to occur only if the threshold condition on the interval to the next word is met.[76]

Although the phenomenon of secondary rise could in part be motivated by a stylistic preference for smaller intervallic jumps within musical phrases, it probably reflects a genuine process of pitch assimilation in fluent speech. First of all, given the very high level of strictness with which the musical settings respect linguistic pitch excursions in regard to accentual peaks and postpeak falls, the subordination of the grave, and the Mid-tone status of preaccentual syllables, and the further principles to be discussed in subsequent sections, it is extremely unlikely that the music could simply impose an out-and-out reversal on a linguistic pitch pattern, turning pitch falls into rises. Secondly, as established in section 2.3.3, there are two distinguishable segments in the peak to valley accentual excursion, HL_1, which is considerably steeper and therefore more salient, and L_1L_2, which is significantly flatter than HL_1, and even flatter in clause and phrase final position. It follows that HL_1 by itself is a sufficient signal of the accent, so that the slope of L_1L_2 would be free to vary, at least under certain conditions, in anticipation of the following word initial syllable. Under normal circumstances (i.e. in the absence of focus or emphasis effects), the pitch of the initial syllable of the following word, I, would not be so much higher than L_1 that a continued shallow fall to L_2 would produce an extremely abrupt jump from L_2 to I. If, however, I were abnormally raised, e.g. due to focus, the turning point between falling and rising pitch could be moved leftwards, thereby creating a shallower valley and spreading the steep rise over more syllables. The slope of L_1L_2 would then change from falling to rising, thereby smoothing the pitch movement from Low to High within a phrase. In other words, the change from a falling to a rising slope of L_1L_2 is naturally interpreted as an assimilatory process, a sort of pitch sandhi, comparable to the pitch sandhi effects found in other languages (section 1.2). This interpretation of secondary rise as assimilation may be represented schematically as in Figure 9:

[76] Since the magnitude of the interval is correlated with the pitch of the following word initial syllable and that pitch is correlated with the syllable's status as accented or unaccented, there will automatically result a correlation between secondary rises and following accented syllable; in P.19 and P.20 53.33% of the relevant word pairs show a secondary rise when the second is initially accented, but only 25.81% when the second does not begin with an accented syllable. In the musical settings, however, it does not appear that accentuation, rather than simply the pitch of the word initial syllable is directly relevant in conditioning secondary rise. Of the initially accented syllables that give an interval at or above the three semitone threshold, 75% induce a secondary rise on proparoxytones and properispomena, but 67% of the unaccented initials meeting the threshold condition also induce a secondary rise. The number of cases is too small to establish the significance of the difference.

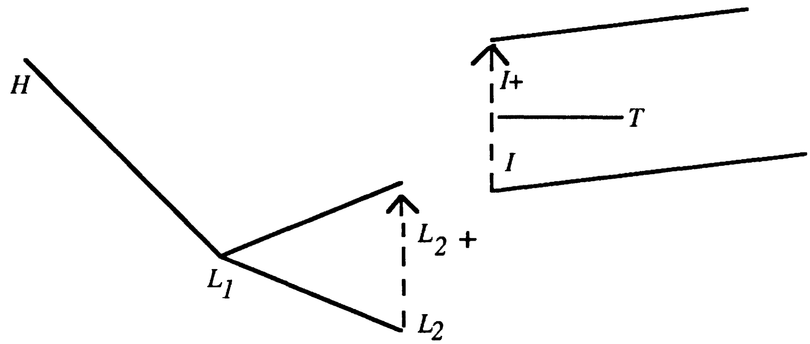
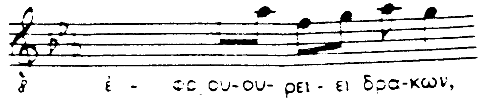


Figure 9: Schematic representation of secondary rise, L_2 to $L_2{}^+$, induced by a rise of the following initial syllable I over a threshold T to I^+.

The foregoing account of secondary rise as an assimilatory process of Greek speech is strengthened by evidence that the secondary rises observed in the Delphic hymns are linguistically conditioned. A large majority of the word initial syllables set at or above the threshold interval (even the few which do not occasion secondary rise) occur either in proper names, which generally occasion abnormal pitch obtrusion in the hymns (see section 2.3.7) or in situations of nonbasic word order associated with emphasis, such as prolepsis or adjective fronting or the like (see section 2.3.7).

There is an additional consideration which supports our account of secondary rise. Even if secondary rises might occasionally be musically conditioned by initial syllables that meet the threshold condition for musical rather than linguistic reasons, insofar as they remain analogues of rises in speech produced by a process of pitch sandhi, we would not expect them to occur in the music under conditions in which such a sandhi process would have been blocked in the language, despite the occurrence of a following initial syllable meeting the threshold condition. One environment that would be expected to block pitch sandhi would be a major syntactic boundary, located somewhere along the hierarchy: finite clause, participial phrase, and long, complex conjoined noun phrase containing predicative material, particularly when sentence final, (so that its phonological phrasing would likely correspond to that of clauses). Due to the nature of the surviving data from the hymns, reliable inferences concerning distributional restrictions on secondary rises in proparoxytones and properispomena cannot be made. One can only observe that whereas they occur at the ends of participial phrases in two cases, they never occur at the ends of clauses. In general it is expected that pitch rises within an immediately postpeak syllable would be more constrained than rises on the syllable following the first postpeak fall. Consequently, it is not surprising that a very clear distributional restriction emerges when we examine rising melisms on paroxytones, including those arising by elision, such as:

P.19.22



P.19.26

We would expect that even when the following initial syllable meets the threshold condition of D ≥ 1.5 tones, such melisms would be significantly more frequent in positions internal to the syntactic phrases enumerated above than in final position in those phrases. To test this deduction we crossclassified just those paroxytone words that end in a heavy syllable and are followed by initial syllables meeting the threshold condition according as their final syllables bear a rising melism or are set to a level pitch and according as they are final or nonfinal in their syntactic units. The results are given in Table 15.

	#(...)$\acute{S}\bar{S}$# #S..., D ≥ 1.5	
	Rising Melism	No Melism
Internal	4	3
Final	0	7
	p = .035	

Table 15: Rising melisms on paroxytone words are constrained to internal syntactic positions.

Despite the rather small number of observations,[77] the value p = .035 (calculated by the hypergeometric distribution) shows that there is a statistically significant constraint on their distribution: rising melisms are excluded from final position in major syntactic units even when the threshold condition is met.

Consequences for reconstruction, 10: the test results of Tables 14 and 15 indicate that, within clauses or phrases, but not across their boundaries, the movement from a Low tone in one word to a High tone in the next could be smoothed by anticipating the High tone via a secondary pitch rise on the L_1L_2 portion of the postpeak trajectory of the preceding word. This reconstruction is represented schematically in Figure 9 above.

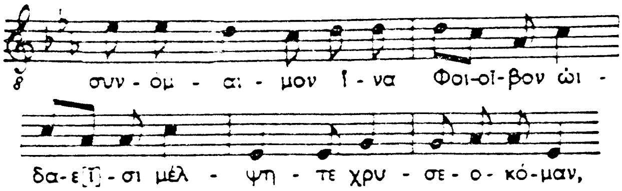
2.3.5. Downtrend

As pointed out in section 1.2, almost all languages have some sort of downtrend in declarative utterances. Downtrend is very strongly respected in the Delphic hymns. It is typical for a clause or major phrase to have its highest

[77] It is very likely that the melism set to the final syllable of ἐφρούρεις P.20.31 was also a rising one, since the following δὲ is set 8.5 tones higher than the preserved, first note of the melism.

pitch on the first lexical, nongrave accent, after which the pitch of the peaks and the valleys falls all the way to the end of that clause or major phrase. In fact, when proper names are excluded, out of all the clauses or major phrases in the two hymns in which the setting of the first lexical acute or circumflex is preserved, that pitch is the highest in the clause or phrase 71% of the time. At the beginning of the next clause or phrase, the pitch level is reset, often somewhat lower in successive clauses or phrases within the same periodic sentence, so that periodic sentences often consist of hierarchically structured downtrend domains. The simplest and best preserved example of downtrend within a domain is probably the relative clause beginning with proleptic συνόμαιμον:

P.19.2–3



A more complex example, since it involves nonlexical words (on which see section 2.3.7) and a proper name, is the clause beginning ὁμοῦ δέ νιν:

P.19.12–14

The major prerequisite for a controlled and unbiased test of downtrend in the Delphic hymns is an explicit specification of its domains in syntactic terms, for it would be circular to define the domains by the points at which there occurs a rise from one accentual peak to the next. More detailed considerations of the specification of downtrend domains are reserved for section 2.3.6. For the present, we will make only the minimal and uncontroversial assumption that the beginnings and ends of downtrend domains coincide with the beginnings and ends of finite clauses, such as final clauses, relative clauses, coordinate clauses connected by δὲ, καὶ, etc., and of complex, branching participial phrases.[78] We therefore neglect the possibility that more than one downtrend domain may occur within these syntactic structures with the result that instances of domain initial pitch reset may be counted as exceptions to downtrend. Thus our tests will be conservative, in fact biased against the hypothesis that the musical settings respect linguistic downtrend. With this definition of domain, we test the reality of downtrend in the hymns by calculating the mean interval between the accentual peaks of acute and circumflex syllables in pairs of immediately successive words. Since nonlexical words and proper names have special properties

[78] Infinitive phrases do not occur in the hymns.

to be established below, they must be excluded. Table 16 reports these mean intervals, denoted P_1P_2 separately for P.10 and P.20.

P.19	P.20
$P_1P_2 = -.44$	$P_1P_2 = -.60$
$s = 1.18$	$s = 1.27$
$P_1P_2 < 0$: $t = 1.81$, $df = 23$	$P_1P_2 < 0$: $t = 2.33$, $df = 23$
$p < .05$	$p < .025$

Table 16: The interval between successive accentual peaks is significantly less than zero.

Each hymn shows a statistically significant tendency for the accentual peak to fall from the first to the second of two lexical words in immediate succession. The difference between the mean falls in the two hymns is not significant, and the grand mean is just a little over a semitone.

Downtrend can also be observed in the (absolute) pitch valleys of successive lexical words. Using the same sampling criteria as for Table 16, but now excluding word pairs the last of which is final in its clause or major phrase (so as not to incorporate any contribution from terminal fall), the corresponding means for the interval between the lowest postpeak pitches of successive words, denoted V_1V_2, are given in Table 17.

P.19	P.20
$V_1V_2 = -57$	$V_1V_2 = -24$
$s = 1.39$	$s = 1.66$
$V_1V_2 < 0$: $t = 1.06$, $df = 19$	$V_1V_2 < 0$: $t = 0.62$, $df = 18$
$p > .05$	$p > .25$

Table 17: Mean intervals between pitch valleys in successive words is less than zero.

Interestingly, in neither hymn is the mean interval between successive valleys significantly less than zero. The means do not differ between the two hymns. The difference between the grand mean, –0.41, and zero is just at the .05 level of significance ($t = 1.69$, $df = 39$). The valley to valley grand mean, furthermore, is not significantly different from the peak to peak grand mean, but especially in view of the data from P.20, it seems that the tendency for the pitch of successive valleys to fall is not so strong as for successive peaks. Data on preaccentual Mid tones, M_1, in two successive, fully accented lexical words (not proper names) are much less extensive than for accentual peaks and valleys, so that the mean difference between $M_{1,1}$ and $M_{1,2}$ will be more subject to statistical noise, with the result that it is not informative to compare the magnitudes of the three mean differences, $M_{1,1}M_{1,2}$, P_1P_2, and V_1V_2. Nevertheless the mean difference between the pitches of the lowest tones of the immediately prepeak syllables of two successive lexicals is significantly less than zero. Thus catathesis lowers all the pitches of a word following a full accent, initial Mid tones as well as accentual peaks and valleys.

Consequences for reconstruction, 11: the test results of Tables 16 and 17 along with further tests of postpeak pitches indicate that there was a strong process of downtrend in ancient Greek. Within domains that correlate strongly with syntactic units, all of the pitches, Mid, High, and Low, fall progressively from one fully accented word to its immediate successor, if fully accented. This reconstruction is represented schematically in Figure 10 of section 2.3.5.1 below.

As pointed out in section 1.2, catathesis does not merely lower pitch, but also progressively compresses the range of accentual excursions: the peak to valley measurements will be smaller farther into a catathesis domain than at the beginning. This effect of catathesis is most clearly demonstrated by comparing the maximum peak to valley interval for lexical words (not proper names) which stand in absolute initial position in downtrend domains, e.g. νηνέμους P.20.9., with the corresponding interval for lexical words which follow them immediately with no intervening accent of any kind. The beginnings of melodic sections are excluded so as not to incorporate any purely musical effect associated with these locations. Table 18 reports the mean peak to valley intervals for the first (P_1V_1) and the second (P_2V_2) in the contexts specified ([$_D$ ___ and [$_D$ A___ , where A means a nongrave accent).

[$_D$___	[$_D$ A___
$P_1V_1 = 2.31$	$P_2V_2 = 1.06$
$s = 1.60$	$s = 0.86$

$$P_1V_1 > P_2V_2\text{: } t = 2.01,\ df = 19$$
$$p < .05$$

Table 18: Compression of peak to valley interval in second of two fully accented lexical words at the beginning of downtrend domains.

The mean peak to valley excursion for domain initial lexical words is over twice as great as the mean for lexical words which follow them. As the t-test shows, a difference this great or greater has less than one chance in twenty of arising at random. The compression effect holds true also when the accentual fall is measured from the peak to the Low of the following syllable or of the second mora of the circumflex if set to a melism, i.e. when the additional pitch fall over the final syllable of paroxytones and properispomena with melisms is discounted. The mean rise to the accentual peak shows a parallel difference. All of the preserved words in question have only one unaccented syllable preceding the accentual peak. The mean rise for lexical words in absolute initial position is $M_1P_1 = 1.61$ tones, but the mean rise for an immediately following lexical is $M_2P_2 = 0.64$. Since there are fewer preserved cases of rise to accentual peaks, this difference cannot be shown to be statistically significant. The preserved data are such that when measurements are extended to the third fully accented lexical word of a string uninterrupted by grave and nonlexical accents no evidence emerges for a chaining effect of catathesis compression; i.e. it cannot be demonstrated that the compression of accentual excursions after n uninterrupted full accents is greater than after $n-1$, for $n \geq 3$.[79]

Consequences for reconstruction, 12: the test results of Table 18 and further data on pitch rise indicate that there was a strong process of catathesis compression of accentual excursions in ancient Greek. The rise to and fall from the peak of the second of two immediately successive fully accented words within the same domain were both smaller than in the first. This reconstruction is represented schematically in Figure 10 of section 2.3.5.1 below.

The distribution of pitch excursions greater than or equal to an octave within words or appositive groups in the Delphic hymns is conditioned by the compression effect of catathesis and the lowering effect of terminal fall. Table 19 lists the instances according to their position in prima facie downtrend domains, which are now defined as whole finite clauses, whole participial phrases, and clauses grammatically complete (in terms of concord, rection, and subcategorization) up to a coordinate major noun phrase containing branching adjective phrases (the single instance at αὐτοχθόνων P.20.19–20). Initial position is defined as the first word or first lexical word if preceded by a single appositive nonlexical monosyllable. The symbols $_{MS}[$ and $]_{MS}$ indicate the beginnings and ends of melodic sections, respectively; they always coincide with periodic sentences of major groups or clauses.

[79] When lexical words, whatever their accentual status and whether proper names or not are numbered consecutively from the beginning of downtrend domains, and nonproper names not immediately preceded by a nonlexical grave are measured for the fall from the peak to the Low of the following syllable or second mora of a circumflex set to a melism, $HL]$, the following means in the ordinal positions are observed: first, $^{1}HL] = 1.98$; second, $^{2}HL] = 1.00$; third, $^{3}HL] = 0.83$; fourth, $^{4}HL] = 1.20$; fifth and following $^{\geq 5}HL] = 1.00$. The difference between $^{2}HL]$ and $^{3}HL]$ holds separately in P.19 and P.20, and is weak evidence for the chaining of catathesis compression on the assumption that lexical graves do not fully block it and that, as it seems, nonlexical graves before the second lexical do not fully block a chaining effect on the third. The increase in $^{3}HL]$ indicates that catathesis compression may be reset, slightly, within downtrend domains. All of this evidence, however, must be treated with great caution, since the music does not provide intervals less than a semitone and cannot permit a compression of its intervallic range beyond the threshold required to sustain a melody and to mark the accentual High-Low movement of the language. Catathesis lowering of pitch in Greek, of course, does chain. See below, note 80.

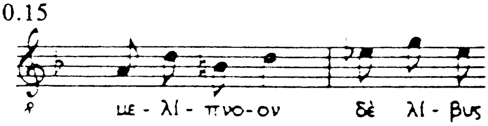
Table 19
Position in Downtrend Domain

Table 19: Distribution of peak to valley interval within words and appositive groups greater than or equal to an octave.

Several striking facts emerge from Table 19. First there are no octave intervals in domain medial position. This exclusion cannot be the result of chance, since there are far more settings preserved in medial position than either initial or final, but is readily explained by the effect of catathesis in progressively compressing the intervals of pitch excursion after the first High-Low within a domain. Second, there are no rises of an octave or more in final position, because the compressing effect of catathesis on the rise to the accentual peak is at its strongest there. Third, the permissibility of falls of an octave in final position is explained by terminal fall, described in section 1.2. That such falls are not restricted to the ends of periodic sentences (e.g. P.20.13, P.20.19–29) suggests that terminal fall may have occurred at the ends of certain domains within periodic sentences and/or that in the musical settings it was generalized to those domain ends. Fourth, the permissibility of both rising and falling octave intervals in initial position reflects the fact that this is the position where both rising and falling accentual excursions are the greatest, because there has been no compressing effect of catathesis. Thus, while excursions of an octave presumably reflect some degree of musical exaggeration of those typically found in unemphatic speech, their distribution directly corresponds to the distributional patterns of the largest excursions of the spoken language.

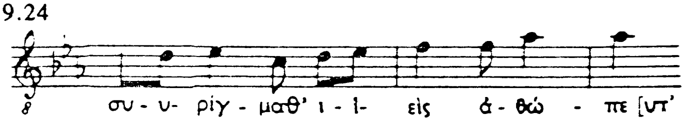
The grave accent, particularly of nonlexical words, behaves quite differently from the acute and circumflex accents of lexical words in regard to catathesis. The results of Table 5 in section 2.3.2, that the grave accent has a lower pitch than the subsequent nongrave accent, mean that the grave does not trigger catathesis lowering; only the High-Low movement of full accents, i.e. the acute and the circumflex, causes such lowering. More interestingly, the grave accent also blocks the lowering effect of catathesis that would be expected to be caused by a preceding High-Low accentual movement. Thus it is often observed in the Delphic hymns that even within a downtrend domain there is a rise in pitch from one acute or circumflex to the next if a grave intervenes between them. As examples consider

P.20.15



with a rise of two and a half tones between the acutes, and

P.19.24



also with a rise of two and a half tones between the acutes, instead of the typical fall (see section 2.3.7). The peak pitches of lexical words following an acute phonetically deprived of its corresponding valley by elision are preserved only once in the hymns within a downtrend domain:

P.19.5–6

In this case there is a fall of a tone between the preceding acute on ἕ- and the following circumflex peak on -ταῖς, rather than the rise which is typical when a grave intervenes between full, accentual peaks. It is unclear whether such an acute followed by elision constitutes an abstract High-Low in phrasal planning, i.e. whether, in terms of ordered rules, catathesis occurs before or after elision; at any rate it does not appear to block catathesis induced by the preceding full accent. Table 20 compares the mean interval between the accentual peaks of fully accented, High-Low pairs, A_1A_2, in immediate succession within the same clause or major phrase, type νιφόβολους πέτρας P.20.3 and the corresponding mean in pairs separated by a grave, A_1gA_2, type ἀμβρόται χειρὶ σύρων P.20.25. Both lexical and nonlexical graves are included. Proper names are, of course, excluded from the peak to peak measurements. The data comprise the relevant instances in P.19 and P.20. P_1gP_2 denotes the mean in pairs with an intervening grave.

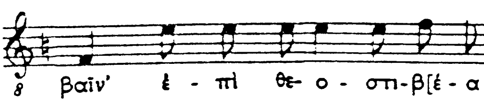
$A_1\ A_2$	$A_1\ g\ A_2$
$P_1P_2 = -.52$ (fall)	$P_1gP_2 = +.50$ (rise)
$s = 1.22$	$s = 2.49$

$$P_1P_2 < P_1gP_2 : t = 1.99,\ df = 57$$
$$p < .05$$

Table 20: The mean peak-peak interval is a falling one when two full accents are in immediate succession, but a rising one when a grave intervenes.

The results of the comparison confirm the hypothesis that an intervening grave blocks downtrend. In fact this configuration is associated with a mean rise of a semitone between the first and second peaks of the two full accents. Although the greatest rise between lexical accentual peaks is observed in this configuration, the very steep rise of a seventh to the grave is probably due to deaccentuation of the elided imperative (see section 2.3.6 below):

P.20.22



Consequences for reconstruction, 13: the test results of Table 20 indicate that an intervening grave accent blocked the downtrend effect of catathesis and, in fact, caused a rise in pitch in the following fully accented word. This reconstruction is represented schematically in Figure 11 of section 2.3.5.1 below.

It appears that the grave accent of nonlexical words such as αἳ, δὲ, ἐπὶ, σὺ, has a stronger blocking effect than the grave of lexicals, such as χειρὶ.

When a nonlexical grave separates two fully accented lexicals, the peak of the second accent averages 0.83 tones higher than the peak of the first, but when a lexical grave intervenes the second peak is only 0.10 tones higher than the first, e.g. συρίγμαθ' ἱεὶς ἀθώπευτ' P.19.24.[80]

Unfortunately, damage to the inscriptions disproportionately affects the settings of the postpeak valleys in these configurations, so that the sample is too small to make a reliable inference concerning the effect of an intervening grave on the interval between the valleys in successive High-Low word pairs. Nevertheless, it is interesting that an intervening grave seems to reduce the mean fall between successive valleys to zero, as compared to the mean fall of 0.41 tones between the valleys of immediately successive peak-valley pairs. It is possible, therefore, that the major effect of an intervening grave is greater on the peak to peak intervals, with a smaller effect on the valley to valley intervals.

Parallel to its blocking effect on the catathesis lowering of accentual peaks, we would also expect the grave accent to have an inhibiting effect on catathesis compression of peak to valley excursions within words. This is certainly true of the grave accent of nonlexical words such as αἲ, δὲ, ἐπὶ, σὺ. This inhibition of compression is most easily demonstrated by measuring the interval from the accentual peak to the Los of the following syllable or of the second mora of circumflexes when set to melisms. In other words, we measure only the interval covered by the steeper straight line segment of the entire peak to valley interval, ignoring the flatter tail of the second syllable of proparoxytones and properispomena set to melisms. Only lexical words which are not proper names and which do not stand in final position are included. Table 21 compares the mean of this interval for words preceded by the grave of a nonlexical word, gHL_1, with the mean for words preceded by a lexical acute or circumflex, AHL_1.

Nonlexical Grave Precedes	Lexical Full Accent Precedes
$gHL_1 = 1.69$	$AHL_1 = 1.02$
$s = 1.59$	$s = 0.95$

$$gHL_1 > AHL_1 : t = 2.00, df = 60$$
$$p \approx .025$$

Table 21: The interval of postaccentual pitch fall is greater when a nonlexical grave precedes than when a lexical full accent precedes.

80 It is instructive also to compare the above data with the observed mean falling interval between the first and the third accentual peaks in strings of three uninterrupted, fully accented lexicals which are not proper names (type γλαυκᾶς ἐλαίας θιγοῦσ' P.20.6): $P_1P_3 = -1.33$ ($s = 1.57$, $df = 14$). This fall of one and a third tones over a full lexical accent is a significant lowering as compared to the rise of 0.10 tones over a lexical grave ($t = 1.75$, $df = 18$, $p < .05$). Thus there can be no doubt that lexical graves do not trigger the catathesis lowering of following pitches that full lexical accents do. This difference between full and grave lexical accents cannot be ascribed to a difference in the syntactic configurations: both the second + third fully accented lexicals and the grave lexical + lexical data sets consist primarily of Noun + Modifier or Object/Adjunct + Verb (or in the reverse orders).

The mean pitch fall from the accentual peak to the first Low following it is over a semitone greater when a nonlexical grave precedes than when a lexical full accent precedes. As the *t*-test shows, this difference is statistically significant. The inhibition of catathesis compression by nonlexical graves is not caused by averaging in the effect of proclitic graves such as ἀνὰ, ἐπὶ, and ἠδὲ. In fact when proclitic graves are excluded gHL_1 increases to 1.92 tones. In contrast to the grave of nonlexical words, the grave of lexical words, e.g. κλυτὰ μεγαλόπολις P. 19.9 and ἰεὶς ἀθώπευτ' P. 19.24, has no effect on catathesis compression. The mean when a lexical grave (*G*) precedes is GHL_1 = 1.06, which is indistinguishable from AHL_1 = 1.02.

Two aspects of the inhibiting effect exerted by nonlexical graves on catathesis compression can be distinguished. On the one hand, such graves do not trigger catathesis. This can be seen by comparing the mean interval as above for lexical words (not proper names) which are preceded by just one lexical word having an acute or circumflex at the beginnings of downtrend domains, $[_DAHL_1$, and the mean for lexicals preceded by one or two nonlexicals bearing the grave at the beginnings of downtrend domains, $[_D(g)gHL_1$: we observe $[_DAHL_1$ = 1.06, but $[_D(g)gHL_1$ = 2.01. The difference is nearly a whole tone, and the mean for lexicals preceded by nonlexical graves is only slightly less than the mean for the total peak to valley interval of lexical words in absolute initial position, $[_DP_1V_1$ = 2.31 from Table 18.[81] We may conclude, therefore, that the High-Low movement of full accents is required to trigger catathesis. On the other hand, nonlexical graves block the catathesis compression that a preceding full, lexical accent would have in the absence of an intervening grave. In the string fully accented Lexical + Nonlexical grave + fully accented Lexical the mean HL_1 for the second lexical is 1.90, which is significantly greater than the mean AHL_1 = 1.02 from Table 21 ($t = 1.89$, $df = 49$, $p < .05$). Nonlexical graves have no discernible overall effect vis-à-vis lexical full accents on the rise from the prepeak pitch to the accentual peak, and it is probably chance that the mean rise after lexical graves is slightly greater than after nonlexical graves. When only strings of fully accented Lexical + grave (±Lexical) + fully accented Lexical are considered, the average rise to the peak of the final Lexical full accent is just over 0.23 tones greater than in strings of fully accented Lexical + fully accented Lexical.

> *Consequences for reconstruction, 14: the test results of Table 21 and additional data indicate that the grave accent of nonlexical words not only did not trigger catathesis compression of pitch excursions in a following, fully accented word, but also blocked the compression effect that a preceding full accent would have had. This reconstruction is represented schematically in Figure 11 of section 2.3.5.1 below.*

[81] There are too few instances of lexical graves at the beginning of domains and immediately preceding fully accented, lexical words to establish statistically whether such lexcial graves trigger catathesis. Nevertheless the mean $[_D(g)GHL_1$ of the three cases when lexical graves precede is less than the mean of $[_D(g)gHL_1$.

2.3.5.1. Discussion of catathesis and the effect of the grave accent

It is the High-Low movement of the acute or circumflex accent that triggers catathesis. The effect of catathesis in a pair of medially accented trisyllables may be represented as in Figure 10.

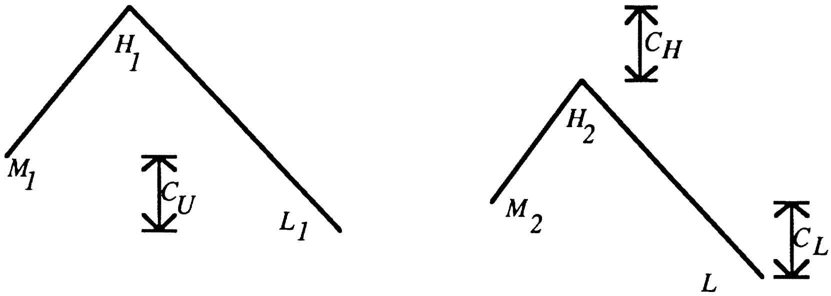


Figure 10: Representation of two trisyllables in a catathesis domain, each with the acute on the medial syllable. C_H represents the effect of catathesis in lowering the peaks, C_L the effect in lowering the valleys, and C_U the word internal effect of lowering the postpeak valley vis-à-vis the word initial unaccented syllable.

The fall from the first accentual High tone, H_1, triggers a lowering of the tones to the right of H_1. Expressed in semitones, the result is the catathesis factor $C_H = H_1 - H_2$ for accentual peaks and $C_L = L_1 - L_2$ for valleys. Since $C_H > C_L$, the effect will be to compress the interval of pitch excursion in the second word by $C_H - C_L$ semitones. Catathesis can be regarded as applying within the High-Low sequence of the accent. This interpretation has the advantage of explaining, at least in large part, why preaccentual syllables appear as Mid tones. Both the pre- and the postaccentual syllable (or morae) may be regarded as phonologically Low tone. Catathesis, however, lowers the postaccentual Low by the factor C_U, thus making the preaccentual syllable seem to be a Mid tone in relation to it: $M = L + C_U$.

The effect of the grave accent on catathesis may be represented schematically as in Figure 11:

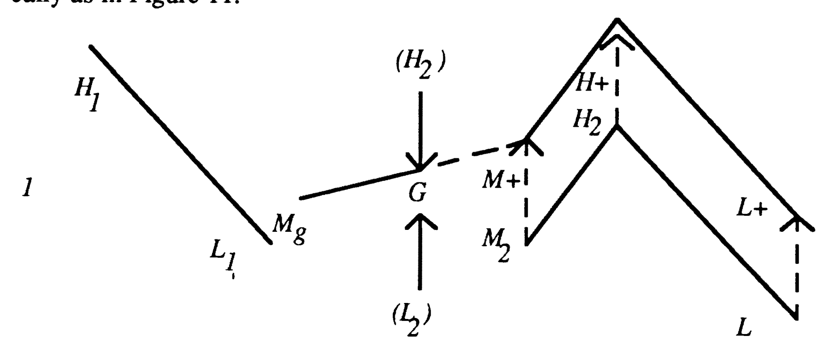


Figure 11: Schematic representation of the blocking effect of the grave on catathesis.

Figure 11 represents the accentual excursions in a string consisting of trisyllabic paroxytone + disyllabic grave + trisyllabic paroxytone words. Only the relative pitches of the M(id), H(igh), L(ow), G(rave), and its preceding Mid, M_g, are represented. The figure is not drawn to scale, and no attempt has been made to represent the differences among the slopes of the lines M_1H_1, M_2H_2, and M^+H^+, or among H_1L_1, H_2L_2, and H^+L^+. M_2, H_2, and L_2 are the pitches that the second trisyllable would have had if no grave word had intervened. M^+, H^+, and L^+ are the higher pitches which the second trisyllable has when a grave word separates it from the preceding fully accented word. The initial unaccented syllable of the second trisyllable, M^+, is represented here as slightly higher than the grave, since it is on the average a little less than a quarter tone higher. The fact that it is frequently set to the same pitch is indicated by the dotted line of rather flat slope connecting G and M^+.

The grave does not trigger catathesis because it is not a full accent: it lacks the fall to a low tone in the same word. It is more problematic why the grave seems to block the effect of catathesis that a preceding accentual High-Low movement would be expected to have, and in fact reverses the movement from downtrend to uptrend. The simplest hypothesis is that, at least under certain circumstances that will be addressed below, a word bearing the grave accent combines with a following, fully accented word in the same downtrend domain to form a single accentual trajectory. Such a process would parallel the tendency in Japanese for an unaccented word, i.e. a word with no HL fall, to be merged into a single accentual phrase with the word following it. The hypothesis of a single accentual trajectory would explain why an initial, unaccented syllable of a following lexical is almost never lower than the preceding grave, but in fact about a quarter of a tone higher on the average (see Table 13 of Section 2.3.2). The rising trajectory, counting from the first syllable of the grave word, obviously covers more syllables and morae than when there is no grave word. Since, as we have seen in section 2.3.3, the magnitude of the accentual excursion tends to increase with the number of pre- and postaccentual syllables, the effect will be to raise the following peak. Even when the grave word is a monosyllable the effect will be substantial, because the trajectory of rise will begin at a higher pitch than it would if the valley of a fully accented word preceded.

The hypothesis that grave + fully accented word can form a single accentual trajectory is strengthened by evidence that such trajectory formation is promoted by the same types of lexicosyntactic factors which are known to promote other sandhi processes such as elision, resyllabification of final vowel + consonant, positional lengthening ($\breve{V}$ #CC-), and the rhythmic integration characteristic of syntagmata at metrical bridges and split and divided resolution and substitution. First of all, we have observed that nonlexical graves boost the following accentual peak to a greater extent than lexical graves. Furthermore, all of the nonlexical graves in the grave + Lexical strings whose pitches are preserved are prepositive (although only a minority are proclitics), with the sole exception of δὲ; but it is well known that δὲ is far more subject to elision, both in prose and verse, than lexical words, and that it occasionally stands before Hermann's bridge. Thus the nonlexical grave words in our data are just those that would be expected to enter into phonological processes with a following word. Since on average lexical grave words also block downtrend, to some extent they too, of course, must permit the formation of a single accentual trajectory. Our hypothesis implies that the effect will be greater in more cohesive syntactic configurations. This implication is confirmed, for eight of the nine cases are either Noun + Modifier/Modifier + Noun (e.g. Λατὼ μάκαιρα P.20.5, κλυτὸν παῖδα P.19.18) or Object + verb (e.g. ἀρχὰν αὔξετ' P.20.39). The sole exception is χερσὶ γλαυκᾶς ἐλαίας P.20.6. Thus 89% of the lexical graves belong to the tighter sorts of syntactic configurations which are known to promote sandhi processes such as elision, resyllabification, and positional lengthening even between lexical words.

2.3.6. Pitch reset

As noted in section 1.2, longer utterances such as the Greek periodic sentence, can contain more than one downtrend domain, pitch being reset, generally somewhat lower, in subsequent domains. To test for the reality of this principle in Greek, we must first establish that reset occurs in syntactic structures which are uncontroversial as potential downtrend domains, and only then consider what smaller structures may also have been, variably, downtrend domains. Accordingly, not to prejudice our test in favor of the hypothesis of domain initial reset, we will at first limit ourselves strictly to finite clauses and complex participial phrases, excluding such structures within them as branching noun phrases, prepositional phrases, etc. If pitch reset at the beginning of clauses and participial phrases is respected in the musical settings, we would expect that the interval between the (nongrave) accentual peak of the last word of a clause or phrase and the first word of the next within a periodic sentence would show a significant tendency to rise, in contrast to the established tendency to fall within clauses and phrases. Again we limit the test only to lexical words, but in order to obtain an adequate sample size we must now include proper names. This inclusion will not bias the test in favor of the hypothesis, since five of the six proper names included occur at the end of the preceding domain, only one at the beginning of the following (ἀπταίστους, Βάχχου P.20.37, and the rising peak-peak interval here of 3.5 tones is in fact less than the peak-peak interval for Ἑλικωνίδας· μέλπετε δὲ P.20.3–4, where the proper name is domain final). In addition to instances such as κρέκει· χρυσέα δ' P.19.15, in which the final and initial lexical words are in immediate succession, we also consider cases such as κυδίστα· καὶ ναέτας, in which they are separated by one or more nonlexical words. Cases involving the ends of periodic sentences and melodic sections are, of course, excluded. Table 22 reports the mean interval $Pf][P_i$ observed, the standard deviation, and the relevant test statistics.

Peak-Peak Interval across Syntactic Boundaries

$$Pf][Pi = 1.05$$
$$s = 2.38$$
$$Pf][Pi > 0: t = 1.97, df = 19$$
$$p < .05$$

Table 22: Demonstration of pitch reset at the beginning of major syntactic units.

The results confirm the hypothesis that the pitch of the first lexical acute or circumflex accent in a clause or major phrase is reset higher than the acute or circumflex at the end of the preceding syntactic unit. In fact out of the 20 cases considered, only three show a falling peak-peak interval; two of them fall by only a semitone, but one, τρίποδα, βαῖν' P.20.22, with a fall of an octave, probably reflects deaccentuation of an elided imperative: the loss of phonological autonomy of elided imperatives is shown by the fact that they behave like clitics for the rules of split resolution and substitution in meter.. If the latter is excluded as an outlier, the mean, obviously, greatly increases, and is far greater than even the mean for clause internal peaks separated by an intervening grave (Table 21 of section 2.3.5). Of course, the mean for lexicals in immediate succession across boundaries significantly exceeds the mean for lexicals in immediate succession within clauses and major phrases ($t = 3.66$, $df = 56$).

> *Consequences for reconstruction, 15: the test results of Table 22 indicate that downtrend ceased at the ends of major syntactic units within periodic sentences, and that pitch was reset higher at the beginning of the next syntactic unit.*

There is also a minor pitch boost, much smaller than initial reset, at the beginnnings of minor phonological phrases. In fact, across minor phonological phrases there is on the average no pitch fall between the peaks of contiguous full accents, whereas within minor phrases there is a mean fall of 1.12 tones.[82] It also seems to be the case that if there is a local rise in pitch, such as pitch obtrusion associated with emphasis on proper names, within a syntactic structure that normally corresponds to a downtrend domain, downtrend starts over from that higher, emphatic pitch. Examples of this phenomenon are provided by:

P.19.6–7

P.19.10–11

82 We discuss the evidence for and syntactic correlates of the minor phonological phrase in our forthcoming paper, "The Greek Phonological Phrase," *GRBS* 31.4 (1990).

P.20.14

In other words, if there is an unusual degree of pitch obtrusion internal to a normal downtrend domain, pitches following that obtrusion do not fall to a level calculated from the previous unemphatic material, but from the new high.

The higher pitch and the absence of catathesis characteristic of initial position in downtrend domains provides a linguistic explanation for a phenomenon which Winnington-Ingram has suggested may be a "licence in the treatment of the accent."[83] Whereas the word internal excursion to the grave accent is, on the average, less than a third of a tone in medial positions in domains (see Table 4), at the beginnings of melodic sections there are two rises of an octave, the clitic group 'Ὁ δὲ P.19.16 and 'Ἀλλὰ P.20.26, and one of two and a half tones, 'Ἀμφὶ P.20.23. Melodic sections, however, always coincide with periodic sentences or at least major groups of clauses. Thus the beginnings of melodic sections are sentence initial, and sentence initial position is the one where pitch rises to its highest peak and the effect of catathesis has not yet begun. Such a linguistic explanation of the large excursions to the grave in sentence initial position also accords with the excursion of one and a half tones to the grave of λιγὺ P.19.14, which is considerably higher than the clause medial average. Furthermore, there is a rise of an octave from the final syllable of χρυσεοκόμαν to ὃς P.19.4, whereas clause medially the rise from an unaccented final to a monosyllable bearing the grave is never greater than two tones, and in one case, ἁγίοις δὲ P.19.11, there is even a fall of two tones.

2.3.7. Local variation and categorical differences in pitch

2.3.7.1. Focus and emphasis

In addition to the sorts of overall variation in pitch discussed in sections 2.3.5 and 2.3.6, there are also local variations within downtrend domains such that there is an increase in pitch level to convey focus or emphasis on a particular word. This sort of emphasis induced pitch rise can be seen quite clearly in the Delphic hymns, particularly as a dampening or in fact reversal of downtrend within downtrend domains. As is appropriate in hymns that also celebrate cult places, theonymns and toponyms are systematic exceptions to downtrend, and, in fact, their nongrave accents tend to be set higher, not lower than or even equal to, the nongrave accents of an immediately preceding lexical word. It is this special, emphatic status of proper names that necessitated their exclusion from the several preceding tests of downtrend and catathesis compression. Table 23 compares the mean interval between the accentual peaks of lexical words in immediate succession within a downtrend domain neither of which is a proper name (*–PN–PN*) with the mean interval between a nonproper name lexical and a proper name (*–PN+PN*). Cases with intervening graves are excluded. The ends of melody sections are, of course, excluded.

[83] Winnington-Ingram (above, note 62) 67n. 3.

$-PN-PN$	$-PN+PN$
$m_{-PN} = -.52$	$m_{+PN} = +.42$
$s = 1.22$	$s = 1.34$

$$m_{+PN} > m_{-PN}:\ t = 2.33,\ df = 58$$
$$p < .025$$

Table 23: Pitch tends to rise from a nonproper name to a proper name in immediate succession, but to fall from one lexical word to the next when neither is a proper name.

The results show that there is a mean rise between the accentual peaks of a nonproper name lexical and a proper name of over four tenths of a tone, whereas there is a fall of about a semitone from the first to the second of two nonproper name lexicals, and the difference is statistically significant.

Consequences for reconstruction, 16: the test results of Table 23 indicate that focus or emphasis was signalled by an increase in pitch level large enough to convert the prevailing downtrend into uptrend on focused or emphasized words.

In addition to proper names, emphatic pitch obtrusion is associated with syntactic movement processes typically used to signal emphasis. This correlation can be seen both when a word initial accentual peak has a higher pitch than the peak of the preceding word and when any initial syllable is set three or more semitones higher than the first of two or more postpeak pitches of the preceding word (cf. section 2.3.4). In the two cases well enough preserved to tell, when a branching noun phrase is moved by prolepsis before a complementizer or relative pronoun, the final word of that noun phrase shows unusual pitch obtrusion. For example, at

P.19.21

the accentual peak of μαντεῖον is, in contrast to the tendency to downtrend, a tone higher than that of τρίποδα, and the initial, unaccented syllable of μαντεῖον is five semitones higher than the first postpeak pitch of τρίποδα and induces a secondary rise on its last syllable. Compare

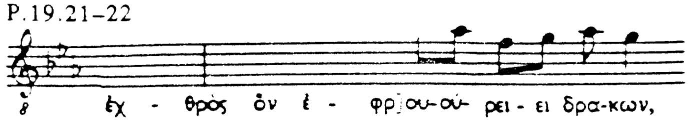
P.20.32

where again the final word of the proleptic constituent induces a secondary rise. When only the adjective of a noun phrase is in prolepsis, moreover, the noun stranded after the complementizer shows unusual pitch obtrusion. The cases are:

P.20.21–22

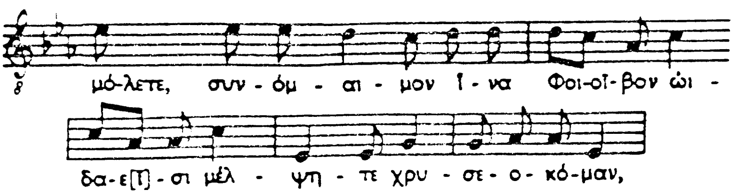
where the accentual peak of the stranded τρίποδα is a semitone higher than the peak of ἔχεις and induces a secondary rise on the second mora of ἔχεις;

P.19.21–22



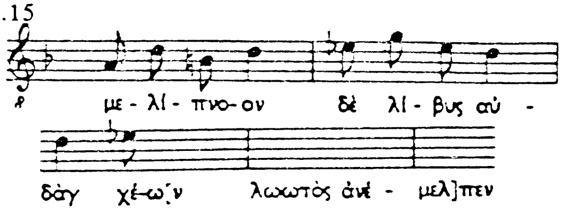
where δρά- does not show a fall relative to the second (and probably the lost highest pitch of the melism set to -φρού-) and is three semitones higher than the first postpeak pitch of -ρει and also induces a secondary rise on it. A stranded adjective may behave in the same way, e.g.

P.19.3–4



It is probably not coincidental that in all three cases of stranded constituents with unusual pitch obtrusion, the stranded constituent is also postposed into the potentially emphatic final position of its clause. Adjective fronting without prolepsis may also be associated with unusual pitch obtrusion. The clearest example is that of λίβυς:

P.20.15



where the λί- of λίβυς is five semitones higher than the -λί- of μελίπνοον, a rise unusually large even in structures involving an intervening grave, and there is a secondary rise on μελίπνοον. Sometimes it is difficult to decide whether a local rise is associated with adjective fronting or with the beginning of a new, minor, phonological phrase, or both, as with μαντεῖον below:

P.19.7–8

There are only a few cases of unusual pitch obtrusion within downtrend domains that are not readily associable with proper name emphasis or syntactic movement rules characteristic of emphasis; the most striking is:

P.20.23–24

(but note that the pitch rise does follow a branching noun phrase). This could be an instance of domain initial reset or it could be an instance of continuation rise, since a parallel participial phrase follows, and both precede the predicate.

2.3.7.2. Distinctions of lexical status

Of great importance for our understanding of the nature of the Greek accent is the existence of a categorial difference in the pitch level of acute and circumflex accents which differentiates lexical words from nonlexical words. There are six cases in the hymns of a nonlexical word or clitic group bearing the acute or circumflex and standing before a lexical word (not a proper name) also bearing the acute or circumflex within downtrend domains. The cases are:

P.19.5

P.19.5–6

P.19.19

P.20.18

P.20.19

P.20.38

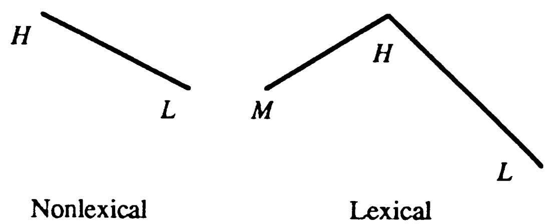
Table 24 compares the rate of 100% at which the peak of a nonlexical is set lower than or equal to the peak of its immediately following lexical with the corresponding, and much lower, rate at which the peak of the first lexical word in pairs of immediately successive lexical words, neither of which is a proper name, is so set. (The data for the pairs of lexical words are the same as for Table 16 of section 2.3.5.)

	$P_1 > P_2$	$P_1 \leq P_2$
NLex + Lex	0%	100%
Lex + Lex	58.33%	41.67%
	$p = .0089$	

Table 24: The peak of a nonlexical acute or circumflex is never higher than the peak of the following lexical acute or circumflex.

The value $p = .0089$ is calculated by the hypergeometric distribution and means that there is only a chance of about nine in a thousand that the exclusion of pitch fall from a nonlexical accentual peak to a lexical accentual peak could arise at random in samples of the same size and marginal frequencies. The same principle of the subordination of nonlexical acute and circumflex accents to following lexical acute and circumflex accents also holds without exception when grave accents intervene and also when the following lexical is a proper name. In fact, as we would expect, the lexical peak tends more often to be higher than the nonlexical peak, if the lexical is a proper name or if a grave intervenes, whereas when these factors are absent the lexical peak is more often at the same level as the nonlexical peak.

Consequences for reconstruction, 17: the test results of Table 24 indicate that the acute and circumflex accents of nonlexical words did not trigger catathesis; rather, nonlexical acutes and circumflexes are subordinated to the full accents of the immediately following word. This reconstruction is represented schematically as follows:



Although there are too few cases for definitive statistical tests, when there is a series of nonlexical words or clitic groups before a lexical, such as:

P.19.12–13

P.20.18–19

the pitch rises from the first to the second nonlexical peak. The only example of a continued rise from the second nonlexical peak to the following lexical peak, P.19.12–13, involves a proper name. Since in the absence of such factors which tend to boost pitch, it is more common for the peak of a single nonlexical to be at the same pitch as the peak of a following lexical, rather than lower, it would seem likely that in the case of strings of nonlexicals plus lexical, there is a rise from the first nonlexical to the second, but that the second had the same pitch peak level with the following lexical, unless the lexical was emphasized or a grave intervened.

The subordination of the acute and circumflex accents of nonlexical words is a manifestation in pitch prosody of the reduced phonological autonomy of (even orthotone) nonlexical words that is demonstrated by their varying permissibility at a number of metrical bridges which exclude lexical word end. Just as the magnitude of accentual excursions to the acute and circumflex of nonlexicals is reduced vis-à-vis that of lexicals of the same length (see Table 9 of section 2.3.3), so too nonlexical acutes and circumflexes do not trigger catathesis lowering of the pitches of following words. Since all of the nonlexicals in question are prepositives, the explanation is that the nonlexicals form a minor pitch group with their host lexicals. Unlike structures of grave + fully accented Lexical, however, a single accentual trajectory is not formed: the High-Low movement of the nonlexical accent is reduced but not eliminated. The idea of the subordination of of nonlexical pitch accents is not only theoretically plausible but also actually paralleled, mutatis mutandis, in Japanese: in sequences of an accented lexcial noun plus an accented postpositive particle, such as róndonmadém 'as far as London,' the particle may be completely deaccented, or it may undergo varying degrees of accentual reduction.[84]

[84] Kubozono (above, note 19).