Cymatics, or the newly **discovered** system in speech where discrete syllabic pitches in words, masked by intonation, mark and differentiate the articulation of **grammatical** and **lexical** classes and configurations in English and other languages.

by Gary Schweitzer Tong

Abstract

Further developing **the importance** placed by **Mertens** (2014) on the syllable in his pitch transcription to indicate "pitch level and pitch movement of individual syllables...or sequences of syllables" it can be shown that in addition to intonational pitch there exists a deeper function, where the sequence of discrete pitches of each syllable, normally masked by intonation, appears as a cyclic wave of pitch levels, consisting of alternating high and low levels typically bridged by mid ones.

This process, termed *cymatic*, functions as muscular actions of the tongue, not as acoustic or spectographic ones. Intonation involves the entire tongue, whereas in discrete syllabic pitch (DSP) only the agency of a specific layer or section of the tongue determines pitch**.** Cymatic analysis provides rigor in estimating lingual pitch levels and yields **novel** and unexpected data, showing that the pitch of **final** syllables of words is a **consistent marker** in grammatical and lexical morphology, in distinguishing parts of speech, in determining word order, in word formation, and in details such as choice of definite article gender in given languages. Cymatics makes available an **advantageous** approach in pitch investigation and its application in learning second languages.

KEYWORDS

pitch, syllable pitch, intonation, identifying pitch, pitch labeling, grammar and word morphology

1. INTRODUCTION

1.1 Current research on pitch

The analysis and labeling of the pitch aspect of intonation has been studied extensively, importantly by (Pike 1945) and others focusing on pitch and stress relationships. Later work included aspects of those relationships in a) nouns contrasting with verbs, b) pitch contrasts in declarative and querying segments, c) pitch fall at cadences, d) differences between languages, etc. More **recently** attention targeted the **labeling** of pitch, especially in text-to-speech, in human-to-machine applications, and in second language learning.

1.2 Current studies in labeling

Pitch labeling has met with several **difficulties** in identifying and correctly **labeling** levels of pitch; there is considerable range of variation in natural speech and often the interpretation of the nature of intonation will be ambiguous. **Several** contrasting systems have been described, working with **varying** numbers of pitches and employing different terminologies all of which lead to considerable complexities.

The range of numbers of recognized pitches includes: a) (Pike 1945) with four pitch levels (The Intonation of American English), b) (Halliday 1967a) with five, cited in INTSINT (Hirst & DiCristo 1998), consisting of three absolute levels plus five modifiers which includes three relative levels and two iterative levels, c) (Campinoe & Veronis 2001) three pitch levels (rising, falling, and level); d) (Mertens 2013) five pitch levels (low, mid, high, bottom, top) plus several pitch movements.

Complexity is increased by working not with pitches *per se* but with pitch accents. This topic was introduced by (Bolinger 1958) in "A theory of pitch accent in English", and taken up by Pierrehumbert (1980) in "The phonology and phonetics of English intonation" and by Beckman & Ayers (1994) in “Guidelines for ToBI labeling: the very experimental html version”. To standardize the large variety of labeling the **ToBI**, (acronym for “tones” and “break indices”) a pitch annotation system was originally proposed by Pierrehumbert in 1980 and became further developed between 1991 and 1994 for mainstream American English. ToBI assigns not pitches *per se*, but pitch accents H*, L*, L*+H, L+H*, H+!H* (plus !H* and L+!H*) and annotates them as break index values 1, 2, 3, 4; uncertainty =x, disfluency – p, tone tier L- H- L% H% %H, plus eight underspecified pitches (* - % 8/ X*? x #- #p) and pitch range HiF0. The system of pitch labeling in **cymatic** analysis employs three levels, low, mid, high and two modifiers low-mid and high-mid.

1.3 Syllables—not targeted by ongoing research

Previous and ongoing research has **not** focused on **labeling** the pitch of discrete syllables for a reason expressed by **Rosenberg and** Hischberg (2009): “Our results indicate that a word-based approach is superior to syllable- or vowel-based detection, achieving an accuracy of 84.2%”. In fact, neglecting individual syllable pitches is perfectly justifiable in real-time speech, where only syllables in emphatically elevated or stressed segments tend to have distinct and easily identifiable pitch.

However, as this paper demonstrates, a specifically designed study of pitch at the syllabic level **yields unexpected** novel data. The starting point for the present work was the considerable importance on the **syllable** placed by **Mertens** (2014). In that work he stated that the detailed objectives of his own transcription of syllabic labeling were:

a) To reach **finer** grained detail in segments down to individual **syllables**: “(This) fine-grained transcription provides labels indicating pitch level and pitch movement of individual syllables...or sequences of syllables”.

b) To distinguish the **nuclear pitch of vowels** in syllables, which define the local syllabic pitch. “In most cases, the alternation of vowels and consonants (or clusters) gives rise to an intensity and sonorance peak during the vowel, characterized by relative spectral stability. The vowel constitutes the syllabic nucleus then.”

c) To try to **isolate** the pitch of discrete syllables from **adjacent** ones because "the exact location of the boundaries between syllables is sometimes unclear...the closure of (a) consonant is part of the coda of a first syllable, whereas the release of that same consonant starts the onset of the next syllable.” Thus syllables are subject to what Mertens calls “**ambisyllabism**” and his solution is to focus on the nuclear syllable.

d) To employ mainly three levels to identify syllabic pitches, low, mid and high (adding two more relating to syllabic levels occurring at boundaries): “of the five pitch levels, three (low, mid, high) are defined on the basis of pitch changes in the local context and two (bottom, top) are defined relative to the boundaries of the speaker’s global pitch range.” This paper similarly keeps to three main pitch levels, plus two modifiers of the mid level, i.e., high mid and low mid, both unrelated to boundaries. This system, like Mertens', significantly reduces the number of variables present in other pitch classifications.

1.4 The present approach based on Mertens' aims extends the technique to labeling discrete, isolated syllables and generally excludes the factor of intonation. The resolution reached is greater than in alternate methodologies. The treatment is unique in that it
a) sufficiently **isolates** syllables to unambiguously define their inherent nuclear pitches, yet allows syllabic boundaries, remaining in the background, to function throughout the articulation;
b) at the same time the technique avoids **ambisyllabism** by preventing input from adjacent syllables;
c) it works with **pitch** as the **single variable**, **excluding** all prosodic elements such as allowed by Mertens (segmentation into syllable peaks, pause detection, pitch stylization, pitch range estimation, classification of the intra-syllabic pitch contour);
d) it designates only three pitches although mid pitch can have two superimposed modifiers, high mid and low mid, which are noted only when significant;
e) shows that **discrete syllabic pitch** is an essential agent in grammatical, phonological and lexical **morphology**. The fact shown in this paper is that language evolution tends to create forms that follow ideal syllabic wave patterns;
f) it demonstrates that the architecture of syllabic pitch sequences is built, like respiration, on regularly cyclic **wave** (or **cymatic**) **patterns**, a fact typically masked by intonation.

1.5 Cymatic behavior

Cymatic behavior, which functions in terms of discrete syllabic pitches (DSP) is the principal subject of this paper. The behavior is observed using a specific method wherein analysis is performed not at the level of normal speech but in an underlying stratum. The technique employs identification of discrete syllabic pitch in words. However, in many cases the wave function can be discovered in the **normally intoned** mode, and, in fact, spectogramic data exist demonstrating cymatic form, see Appendix B. In cymatic behavior the levels of pitches of syllables in a sequence alternate between high and low levels typically separated by mid-pitch levels, similar to waves or pulses, cf. Gk. *kyma*, *kymat-* "wave". A sequence can start at any of the levels, depending on the phonetic content of a word. Below are examples of phrases exhibiting typical cymatic patterns.

1.6 Pitch labeling symbols which precede the syllable are indicated as

high: ¯ (Unicode 00AF) e.g., ¯bring
low: _ (shift+hyphen) e.g., _yard
mid: = (equal sign) e.g., e.g., =red
low and high mid: _= and ¯= e.g., _=tent, ¯=stint
(Once obtained the Unicode character can be cut and pasted).

Examples:
=A¯dam=and_Eve, ¯man=and_wife, ¯bride=and_groom, ¯peace=and=qui_et, =hea¯ven=and_earth, =it¯is_me, ¯scrape, =sore (adj.), =this_is=a¯lamp, _knock (noun), ¯knock (verb), ¯sea_shell, =she¯shells, =the_boy, ¯=re_ject (noun), _=re¯ject (verb)

1.7 Avoidance of ambisyllabism

Labeling discrete syllables has not been possible in existing methodologies since intonation brings to prominence stressed components, whereas for unstressed segments the innate nuclear pitch levels are compressed to approximately the same height where they are not distinctly identifiable, as fig. 1 shows taken from (Mertens 2013).

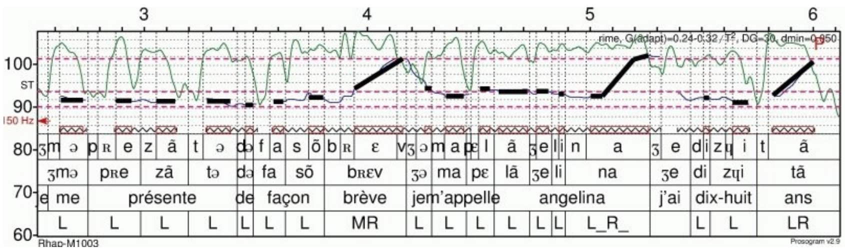


fig. 1 Non-discrete syllabic labeling in (Mertens 2013)

The syllables in “me présente de façon” are all labeled as L, although there exist subtle acoustically perceptible distinctions between their pitches otherwise they would manifest as a monotonous **chan**t, like any stretch of speech lacking minimal syllabic pitch variation. The distinct inherent pitches of these syllables, masked by intonation, are shown at **1.19** example 1.

Hence in fig. 1 interference between syllables occurs, as a process termed “ambisyllabism” in Mertens (2014), referring to the pitches of individual syllables combining in part with those of surrounding syllables: “many sounds may be **ambisyllabic**: the closure of the consonant is part of the coda of a first syllable, whereas the release of that same consonant starts the onset of the next syllable.”

The technique proposed in this paper circumvents such ambiguities by allowing syllabic pitches to independently manifest while maintaining boundaries. A way to fully accomplish syllabic pitch analysis without any interference is a **novel** methodology that expands Merten's’ approach and introduces a new paradigm that may initiate a new field of study.

2. GENERAL DESCRIPTION OF THE METHODOLOGY

2.1 Discrete Syllabic Analysis (DSA)

The method necessarily relies on **proprioception**, the only technique available at this time for DSP analysis. Allowing for the preference for instrumental research, proprioceptive analysis is justifiable as it was an accepted methodology in earlier literature, cf. the following quotes from Bolinger (1958):

p. 14. “Seven listeners were asked simply to indicate the syllable or syllables that they heard as stressed.”

p. 115 “...stresses could not be signaled by them, and finding that nevertheless the stresses were clearly heard.”

p. 120. “This contrast with *single* was put to seven speakers and the majority confirmed the predicted arrangements of pitches as judged by the ear.”

Additionally, employing proprioception as a tool in DSP is amply based. Proprioception has been customary in teaching foreign language articulations, in sensing muscles in athletic training, and in the scientific context as clinical applications in kinesiology, clinical practice and rehabilitation. The latter includes manipulation of prosthetic limbs through somatosensory and mental techniques. Relating specifically to oral articulation "the literature reveals the discrete sensitivity that exists in the separate components of the **masticatory** system" (Robert and Loiselle 1972), and for connecting mastication and speech articulation we can cite that "it has been hypothesized that the skilled movements of the orofacial articulators specific to speech may have evolved from feeding functions (Seurrier et al. 2012). More generally, the importance of proprioception was stated in (Hillier et al. 2015) as: "Current understandings of proprioception from the research literature need to be applied in clinical practice to further implement evidence-based assessment and therefore rehabilitation."

2.2 Discrete syllabic analysis (DSA) for identifying individual syllabic pitches utilizes a specific method **not** previously established and will be presented here. The results are based not on acoustical analysis but on empirical physiological behavior. The focus is on tongue geometry, in establishing in what lingual division the prime mover resides for particular pitches. The discreet syllabic pitch (DSP), is the pitch of the vocalic syllabic **nucleus**. This technique identifies the pitch of each syllable by determining the anatomical location of the **lingual prime mover** for each syllabic nucleus. Ways of empirical verification are available (refer to section 3.8).

2.3 N**uclear pitch** of a single phoneme or of a syllable is definable by the prime mover caused action appearing in either a) one of a given **horizontal** intrinsic lingual muscle layer, or in b) one of a given **axial** lingual section. See 14.6 fig. 2. The muscular primacy of either alternate option depends on the speaker's momentary muscular configuration, including tongue position, head tilt, and such. Either of the alternates is readily available and can be opted and isolated. **Isolation** is necessary because the simultaneous occurrence of both alternates acting as a united mass ambiguates and confuses. Combined tongue regions cannot give data on discrete syllabic pitch.

2.4 Validity of the pitch levels obtained in discrete syllabic analysis would tend to be supported in that according to Pike "In each language...the use of **pitch fluctuation** tends to become semi-standardized, or formalized, so that all speakers of the language use basic **pitch** sequences in similar ways under similar circumstances" (Fischer-Jørgensen 1949). It follows that this applies to syllabic cymatic pitch distribution as well, since the latter constitutes a deeper articulative structure which is the ground for normal pitch fluctuation at the speech level.

3. PRACTICAL METHODOLOGY

3.1 Methodology in general

There are two aspect of the methodology, one pertains to reading in this paper the samples with labeled DSP pitch levels and verifying them. The second one relates with independently determining the DSP levels. A **control** technique is provided.

3.2 Mouthing words

The most direct and unambiguous method to perceive syllabic pitch is to merely **mouth** words, to orally produce them without sound. This mode, importantly, excludes phonation, giving pure lingual pitch articulation. Word(s) are pronounced fully, but syllables must be distinctly articulated, while keeping their boundaries within the total articulating frame of word or phrase. Speech propagation should be slow enough to permit full production of each syllable, allowing each syllable frame to execute its cadences; at such times the syllabic nucleus emerges. It is also important to keep jaw movement minimal, except for labial stops.

3.3 Pitch labeling with jaw release

Another simple method for syllabic pitch identification for monosyllable or syllable in a word is to relax the jaw and letting it drop while holding the articulation frame of the syllable. This neutralizes the oral and phonation frame so that these no longer overpower the tongue action (Gibbs and Messerman 1972), (Serrurier et al. 2012), and (Hiimae et al. 2002).

3.4 Whisper

Another unambiguous technique is articulating in the **whisper** mode. In whispering the **phonation** component of articulation is minimized and it does not influence independent tongue articulation (Coleman et al. 2002). **Evidence** for this fact is that whisper **does contain** pitch. Full speech articulation works with two variables: lingual articulation and laryngeal phonation. Importantly, while phonation is a component of speech production, the primary agent of pitch generation is tongue articulation, which, when isolated, as in whisper mode, remains the **single** variable in defining pitch.

However, note that in whisper the pitch observed will be the **mirror opposite** of that in phonated speech, (low instead of high, etc.) while mid pitch will remain unchanged. It is easiest to observe this when pitches of monosyllables in speech *versus* whisper are compared: ¯ta (normal), _ta (whisper); ¯tip (normal), _tip (whisper); ¯stay (normal), _stay (whisper); _no, (normal), ¯no (whisper); =near (normal), =near (whisper); =and (normal,) =and (whisper).

3.5 Control technique in whisper mode

Pitch identification in whisper can be **further checked** in **normal** articulation, where the pitch will move to the mirror opposite location. **Control** in validation of pitch level is thus available in that levels in normal and whisper are contrary.

3.6 Pitch articulation while reading text

It is observable that visually confronting printed words or text with pitches labeled while articulating increases efficiency of detecting lingual pitches. Hence this is another available methodology. Note that printed text with symbols identifying pitches prepares pitch articulation in the appropriate lingual regions. The reason for this is that apparently visual action attenuates phonation and so allows pure lingual pitch articulation. In fact, visual attention on tongue is equally effective. Wherever pitch is labeled throughout this paper pitch identification should be immediately enabled.

The present material features words and syllables with diacritics marking pitch levels and it may be assumed that readers will accept and articulate them as thus indicated. Such assumption is drawn from the fact that throughout the literature objections are not raised to specific labeling of pitches as they are offered, for instance, in Goldsmith (1981):

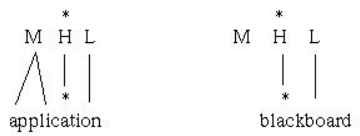


fig. 3 Example of labeled pitches (from Coleman in " An Autosegmental Approach to Intonation" (date unavailable)

Apparently, prior knowledge of the pitch readies the reader to recognize and automatically generate the pitch. This shows that there can be accuracy in identifying pitch when seeing text with labeled pitches. For this reason, by merely mouthing or quietly articulating the samples given below the pitches indicated can be readily generated:

_grape, ¯scrape (verb), =dis_guise (noun), =so¯lu_tion, =flow_er, ¯ye=llow, _don't¯eat=your_food, _the¯great=state_=of¯Wis=con_sin, _a¯part_ment. For symbols refer to 1.6.

Altering the designated pitches degrades the articulation. Identification of syllabic pitches in ongoing speech is not simple because several simultaneous synergic forces interact in the process of ambisyllabism, whereas once the pitches are indicated the difficulty disappears.

3.7 Starting with monosyllabic words

The efficient way to adopt the method for DSP labeling is to initially work with **monosyllabic** words, without consonant clusters or diphthongs. It is also useful in discerning pitch to contrast homophones and homonyms and also parts of speech which differ in possessing high, mid or low pitches. The symbols, which precede the segment, are ¯high, =mid and _low, as well as ¯= high mid and _= low mid. The pitch appears in the syllabic **nucleus**, not as the composite pitch of the entire word. Thus: _tip (noun) vs. ¯tip (verb), _meat vs. ¯meet, _tap vs. ¯tap, _keel vs. ¯leak, =slow (adjective) vs. ¯slow (verb), =sore (adj.) vs. ¯soar (verb), =where (conjunction), =in (preposition) etc.

Working with **polysyllabic** words the significant pitch, which identifies the grammatical nature of the word as part of speech and which defines its cognitive characteristic, always resides in the nucleus of the **final** syllable. Thus: nouns: =dis_guise, =per_mit, =so¯lu_tion; verbs:=in¯vent, =per¯mit, =di¯ssolve; adjectives: ¯spark=ling, =a¯ma=zing, ¯=ye=llow; adverbs: _al=ways, _=be=cause, =ne_ver=the¯=less, etc.

3.8 Experimental control: whisper mode

As it was mentioned in paragraph 3.5, control is available in ascertaining accuracy of pitch level estimation. When the sample is **whispered** phonation is minimized (Coleman et al. 2002) and does not interfere with independent tongue articulation in DSA. Importantly, although phonation is part of the kinesiology of articulation, the primary agent of pitch production is tongue articulation, which, when isolated, remains the **single** variable in defining pitch.

4. METHODOLOGY IN PHYSIOLOGICAL TERMS

4.1 The methodological technique in detail

a. Articulation is to remain a **monotone w**ithout any **intonational** variations, similarly to liturgical or other forms of chanting.

b. The amount of **effort** in articulation and especially in **phonation** should be **minimal**, approximating the level below which speech reduces to **whisper**, which mode avoids phonation (Coleman et al. 2002).

c. The inherent pitch of a syllable appears in the syllabic **nucleus**. No component phoneme in the syllable except the **nuclear vowel** exhibits discrete syllabic nuclear pitch.

4.2 The **nuclear pitch** of a syllable resides in its vowel component. Thus, one should first articulate the syllable, stabilize the nuclear articulative frame and strengthen vocalic articulation. E.g., in syllable "car" the /k/ and /r/ components are attenuated while the /a/ takes prominence producing a low pitch appropriate for nouns.

4.3 Pronounce the segment several times to establish its oral setting in the articulatory frame. Do this is with minimal energy, at a level just **before** entering **whisper** mode.
Allow full emergence of each syllabic nucleus before going to next one, maintaining clear separation of syllables, but without breaking the articulative flow of the word frame. It is important to place **attention** on the tongue, and keeping **jaw** movement **minimal**. The **eyes** should remain only weakly focused, or be closed. Repeating the segment assists the analysis.

4.4 Slowly articulate each syllable of a word in sequence without intonation, as in reciting or chanting. With each syllable **allow** tongue and jaw to reach their natural temporary shapes and resting positions within the syllabic frame. Doing so retains syllabic **boundaries** and preserves the flow of the articulation of the segment.

4.5 The **nuclear** pitch appears at this time as the tongue's **muscular tension** emerges in either a high/mid/low or a front/mid/back tongue division. It is important to **relax** any forces that impede the tongue and jaw configurations from landing in their syllabic nuclear pitch position.

4.6 Syllabic nuclear pitch is identified according to prime mover

In this methodology the syllabic nuclear pitch is identified according to prime mover of action appearing either in **a)** a lingual **longitudinal layer**, or in **b)** a lingual **axial section**. To clearly label syllabic pitch one needs to find its automatically generated anchor, or **intersection** point of the forces within lingual musculature, which appears in either of two different configurations. More specifically, in horizontal tongue layering **a) high** pitch tension is in the superior longitudinal muscle, **b) mid** pitch is in the middle or vertical-transverse layer and **c) low** pitch is in the inferior longitudinal layer. Alternately, pitch anchor exists as **a) high** pitch in the tongue blade, **b)** as **low** pitch in the tongue body, and **c)** as **mid** pitch in the central tongue region shared by the blade and the body, fig. 2.

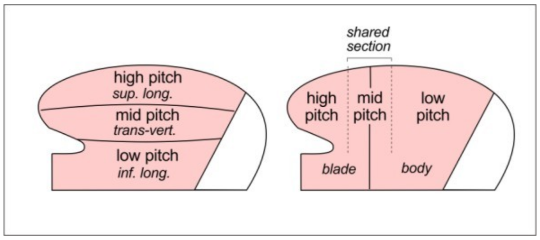


fig. 2 Tongue regions for identifying DSPs

4.7 The **jaw** must be sufficiently **relaxed** to avoid its overpowering of tongue action (Gibbs and Messerman 1972), (Seurrier et al. 2012), and (Hiimae et al. 2002).

4.8 As per examples above in section 3.6 "Pitch articulation while reading text" where pitches are marked, looking at segments with pitch symbols while articulating them significantly aids pitch identification. Apparently, the **visual identification** of the pitch predisposes correct lingual articulating action. Simply put, **prior** knowledge of the syllabic nuclear pitch significantly **enhances** its articulation and identification.

4.9 Significance of the role of final syllable pitch

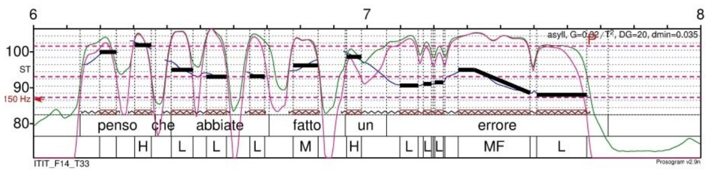
DSP of final syllable is the identifying mark in distinguishing between grammatical elements and between cognitively contrasting words, the latter discussed in manuscript prepared for submission by this author. Therefore, in most cases it is only the **final** syllable pitch that is significant and needs DSP labeling. This is clearly observable in polysyllabic words, such as =per¯mit (verb) and =per_mit (noun), _sub=sti¯tute (verb), =sub¯sti_tute (noun), =re¯verse (verb), =re_verse (noun), =pre¯=di¯cate (verb), =pre¯=di_cate (noun), =in¯sult (verb),¯=in_sult (noun), =in_=den¯ture (verb), =in_=den_ture (noun), =te_=le¯phone (verb), =te¯=le_phone (noun). More on this at 6.11 "Cymatic signature of parts of speech".

4.10 Lingual physiology in identifying DSP

The methodology of the required articulation for identifying DSPs can be most concisely described in terms of parts of speech. With each syllable of a word one stops to maintain its frame while also attenuating the forces of phonation. This allows the articulation frame to settle on the nuclear syllable. Within this frame a small region, or node of tension in the tongue will manifest. It will be either in a longitudinal high/mid/low or in a front/mid/back tongue division of tongue. With verbs the node will be in the **superior longitudina**l muscle layer, while for nouns it will be in the **inferior longitudinal** layer. Adjectives, adverbs and conjunctions assign their identifying pitches in the **middle** (vertical-transverse) layer. In terms of the **axial** divisions of the tongue verbs and nouns assign their index pitches, respectively in the **front** and **back** sections, and adjectives, adverbs and conjunctions in the **mid** section

4.11 Cymatic wave sequences in speech

Pitch, even in normal speech intonation can exhibit cymatic, i.e., undulatory wave patterns. The waves peak in prominent segments carrying significant information and therefore belong to stressed syllables. Less prominent segments occur at lower pitch levels. This can be seen in fig.4.



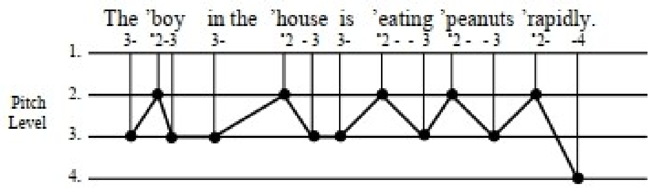


Figure 2.3: An intonation contour defined using primary contours.

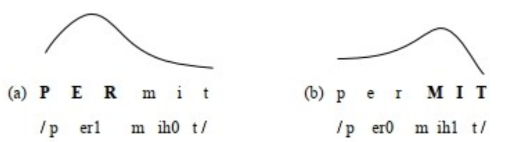


Figure 1: Pitch realization for words *permit* (noun) and *permit* (verb) in citation form (Ladd, 2008).

fig. 4 Examples of wave patterns exhibited in intonation [Sources from top down: (Mertens 2013), (Pike 1945), (Grice 2007), (Li 2016)]

This paper will show that when segments are analyzed for individual syllabic pitch there appears a wave configuration even more well defined and well ordered, with cyclically sequenced high, mid and low pitch levels. It is to be noted that **instrumental** recording is **not applicable** in DSA of ongoing speech since the technique temporarily halts the speech process during the identification of nuclear pitch.

4.12 Examples of DSA pitch identification:

Example 1. One of Mertens' samples (Mertens 2013) can be analyzed applying DSA. In the segment "je me présente de façon brève" the labeling vertically compresses all but one syllable to a nearly identical low level (L). On the other hand, DSA yields a fully developed **cymatic** pattern not of prosodic intonation, but of discrete syllabic cycles:

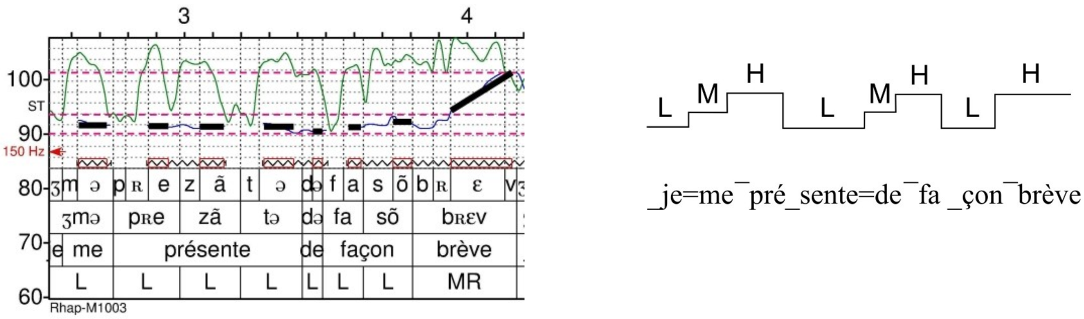


Fig. 5 Cymatic analysis applied to automatic labeling in fig. 1 in (Mertens 2013)

This phrase is an example of a near perfect cymatic form shown as symbols: _ = ¯ _ = ¯ _ ¯

Example 2.

fig. 6 Example of wave pattern in intonation**,** fig. 3 in (Grice and Bauman 2007)

At normal intonation the wave peaks at “schö-” and **“**haus” separated by a trough:
a) =le=na=hat=ein¯**schö=**nes¯**haus=**ge_kauft (with intonation and stress)
Extracted pitch level line is cymatically approximate: = = = = ¯ = ¯ = _

With DSA a full cymatic sequence appears:
b) =le_=na¯hat_=ein¯schö=nes_haus¯ge_kauft (as DSA, without intonation or stress)
Pitch levels exhibit an appropriate wave form: = _= ¯ _= ¯ = _ ¯ _

Example 3.

Although Mertens (Mertens 2004) breaks a sequence into separate syllables to demonstrate **pitch contours**, the technique does not here exclude ambisyllabism and so **discrete** syllabic pitches are not **detached** from pitch levels of preceding and following syllables.

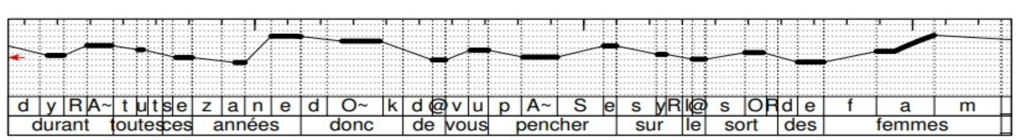


fig. 7 Ambisyllabism shown in automatic labeling (fig.1, Mertens 2004)

In the intonation contour of this figure individual syllabic pitches show ambisyllabically caused compression. In comparing the pitch levels marked with black rectangles with those in the cymatic wave pattern of discrete syllabic pitches the differences can be noted:

DSP: ¯du_rant¯toutes=ce_san¯nées=donc_de¯vous _pen¯cher¯=sur_le=sort¯des_femmes

¯ _ ¯ = _ ¯ = _ ¯ _ ¯ ¯= _ = ¯ _

4.13 Cymatic waves exhibited in intonation

Studies on pitch have often presented prosodic wave processes but have not specified their **cymatic** nature, interpreting them merely as “intonation contours”, cf. fig. 2.3 in Pike (1945):

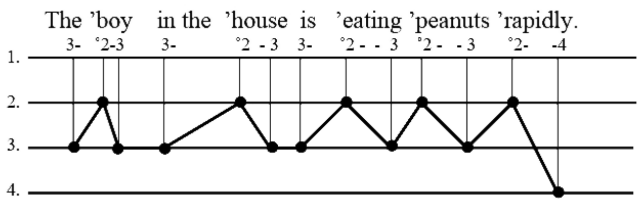


Figure 2.3: An intonation contour defined using primary contours.

fig. 8 Regular wave pattern observable in intonation contour

The above segment, produced with intonation, can be cymatically represented:

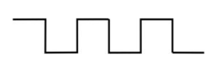
=The¯**boy**=in=the¯ **house**=is¯**ea**=ting¯**pea**=nuts¯**ra**=pid_ly

The same pitch sequence omitting text: = ¯ = = ¯ = ¯ = ¯ = ¯ = _

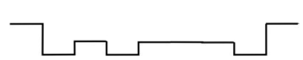
This sentence exemplifies a recognizable, though imperfect wave, intoned on the mid level, with a span of only mid to high pitches, and reaching a low only at the cadence of the sentence.

4.14 Variations in cymatic sequences

Ongoing speech segments, which do not uniformly feature perfect patterns, employ **three** types of waves:

a. perfect sequence or equal cycles ¯ _ ¯ _ ¯ _ or ¯ = _ = ¯ = _ 

b. semi-perfect sequence with two or more adjacent mid pitch subsegments ¯ _ = = ¯ _ 

c. imperfect irregular sequence order ¯ _ = _ = = _ ¯ 

4.15 Examples of the three wave types

a. Good writing, speaking and oratory relies on perfect or near perfect pitch undulations. Perfect sequences of alternating high-mid-low cycles are by definition found in elegant literary prose, where words flow unimpeded. The pitches indicated here are discrete syllabic ones, not those occurring in normal speech where ambisyllabism masks them, e.g.,

1) from William Faulkner’s “A Rose for Emily”:

¯It =was_a¯big=squar_ish¯frame_ house=that_had¯once=been_white

Reduced to pitch symbols: ¯ = _ ¯ = _ ¯ _ = _ ¯ = _

2) from **“**The Shadow of the Torturer” by Gene Wolfe

¯I_have¯=said=that_I=can¯not=ex¯plain=my_de¯sire_=for¯her,=and_it¯is_true.

Reduced to pitch symbols: ¯ _ ¯ = _ = ¯ = ¯ = _ ¯ _= ¯ = _ ¯ _

b. A semi perfect sequence contains abutted mid pitch subsegments and an insufficiency of low pitch cadences, e.g.,

1) from “True Fasting” (Isaiah 58:6 from the Good News Bible):

“Remove the chains of oppression and the yoke of injustice, and let the oppressed go free.” The hortatory mode here gives high pitch on the last syllable of the sentence.

=Re¯move =the¯chains =of _=o¯=ppre=ssion¯=and_the¯yoke=of =in_jus¯tice=and ¯let=the_o¯ppressed =go¯free.

= ¯ = ¯ = _= ¯= = ¯= _ ¯ = = _ ¯ = ¯ = _ ¯ = ¯

2) from *1984* by George Orwell:

=It_was=a¯bright=cold¯day=in¯Ap_=ril

= _ = ¯ = ¯ = ¯ _=

c. Imperfect cymatic sequences typical in **legal** texts are inconvenient to read:

¯If=you¯pub=lish_Your¯Con_tent=in¯a=re=as=of=the¯Ser=vice=where=it=is_a¯vail=a¯ble¯broa=dly¯on =line

=with_out=re¯stric=tions,=Your¯Con=tent=may=ap¯pear=in=de_mon¯stra=tions=or=ma¯te=ri=als=that= pro¯mote =the¯Ser=vice *(from a Microsoft agreement)*.

Reduction to pitches shows long sequences, without rhythmic breaks and with repetitions of extended mid level segments. The many a**cymatic** phrases ending at mid level hamper natural breathing pauses.

¯ =¯=_¯_=¯= = = =¯= = = = _¯=¯=¯= =_ =¯= = ¯= = = ¯= =_¯= = =¯= = = =¯ =¯=

4.16 Are intonation and DSP hierarchically ordered?

DSA **brings to light** a level of speech generation that operates below that of intonation. Stating that DSP surface is "below" the intonation surface only reflects that intonation masks DSP; syllabic pitch levels are compressed by intonation and are not intuitively observable.

Whether there is hierarchical order for intonation and DSP action is undecidable.

Intonation can occur merely cognitively, by setting an oral frame **without any articulation** present; it can be no more than the oral setting of a cognitive intention, as when preparing to ask a question. But **speech does not** yet occur in this case.

At the same time, it is **impossible** to articulate syllables **without intonation** because intonation cannot occur without any cognitive state, even if that is a sense of absolute neutrality lacking any grammatical or psychological attitude, locution in monotony or in merely mouthing words. Thus, intonation and DSP proceed simultaneously. Furthermore, the two materialize through time and so there is an initial step where both functions are already set for running the entire segment. Apparently intonation and DSP are merged synergetic action pair.

Which function is primary or secondary would seem to depend on the relative emphasis given to each, but since stress or pitch in either occur at the same time and are inseparable, it can be said that there is **no hierarchical** ordering of the two actions. A definite answer could only come from neurological analysis.

4.17 The cymatic wave format

DSA shows that speech segments spoken with optimal articulative **efficiency** following the ideal pattern of syllabic phonological and lexical sequence proceed in a cyclically regular **cymatic** ordering. High and low pitches alternate going usually, but not necessarily through intervening mid levels. **Wave** nature of a sequence is evidenced by the cyclic shift (or register shift, see 5.4, 5.5) caused by inserting words, or by stress reassignment or by option of grammatical alternate in order to maintain an orderly undulation. As later described in this paper, application of DSA demonstrates the morphological role of pitch in word formation, word ordering, grammatical functioning, as well as in cognitive aspects of speech. The ideal requirement of **cymatic** format appears to be a **rule** by which a pair of high or low pitched syllables should not be adjacent, but should be separated by one or more steps of mid level pitches.

<u>5. INHERENT SYLLABIC PITCH</u>

5.1 DSP of isolated phonemes

DSP differentiations among isolated self-standing phonemes appear with varying complexity, because the pitch is generally formed by the phoneme's prime mover activating several lingual layers and sections. The clearest examples of differentiation are those between voiced and unvoiced consonant pairs, where the voiced ones are low pitched and the unvoiced are high. To observe this the consonants must be produced with minimal vocalic components.

_/b/ vs. ¯/p/ _/g/ vs. ¯/k/

_/d/ vs. ¯/t/ _/v/ vs. ¯/f/

_/z/ vs ¯/s/ _/ʒ/ vs. ¯/ʃ/

The pitch is less distinct for /j/, /l/, /w/, etc.

5.2 Monosyllables

Each phoneme in a word has a pitch, and these merge into the characteristic pitch of the word.

Pitch per phoneme: "switch" ¯s_=w¯i_ tch (noun) _s¯=w_i¯ tch (verb)

Pitch of word: _ switch (noun) ¯switch (verb)

Monosyllabic words have inherent vocalic nuclear pitch levels. _greed (noun), ¯bird (verb), ¯cut (verb), _cut (noun), _=boar (noun), ¯bore (verb), _pest (noun), _crumb, _=steak (noun), _mail (noun), ¯mail (verb), _=salt (noun), _lamp (noun), _=lamb, =tame (adjective), =since (adverb), etc.

When combined in polysyllabic segments the innate individual word pitches change, as for example with "salt" or "lamp":

¯add =the _salt vs. =take _the ¯salt

=this¯is=the_lamp vs. =this_is=a¯lamp

5.3 Bisyllabic words a) carry inherent pitches per syllable, and b) exhibit mirror pitches in contrasting grammatical homophones:

a) =sten_cil, _=war=_time, =lo_cust, =mois_ture, =sug¯gest,

b) ¯per_mit (noun), _per¯mit (verb) =sub_ject (noun), =sub¯ject (verb), etc.

5.4 Trisyllabic segments and shift

The syllabic pitches of well ordered cymatic sequences appear as undulating peak-trough-peak cycles. They are the base on which the pitch sequence of various segments are overlaid. Determined by the high, low or mid pitch of its initial syllable, the segment is deposited on the wave base to properly align the initial syllabic pitch of the sequence. In the following examples highlighting shows positional overlays of "my permit", "our permit" and "envelope" (noun) vs. "envelop" (verb) and illustrate how half cycle **shifts** take place along the wave base register. Segments in this sample consist of perfect wave patterns. While such formats are not typical in normal prosody, in these instances they demonstrate the wave behavior of syllabic pitch shift. Wave base is represented by line of high and low symbols; stressed syllables are underlined; bold type indicates pitch shifted syllable, not stress.

my **per** mit

_ ¯ _ ¯ _ ¯ _ *wave base*

our **per** mit

_ ¯ _ ¯ _ ¯ _

en ve lope (noun)

_ ¯ _ ¯ _ ¯ _

en ve lop (verb)

_ ¯ _ ¯ _ ¯ _

5.5 Grammatical change and shift in heteronyms

Grammatically contrasting pitch variations in heteronyms undergo **cymatic** register shifts caused by changes in stress placement, changes in inherent syllabic pitches and in changes according to parts of speech.

a. Pitch placement distinction between the contrasting pair ¯per_mit (noun) vs. _per¯mit (verb) is altered in **stress** variation in different lexical contexts, as in change of the personal pronouns, “my” vs. “our” or “I” vs. “you”. Stresses indicated in bold type.

my¯=**per**mit (noun) vs. ¯=our_=**per**¯mit (noun)
¯**I**_per¯=mit (verb) vs. ¯=**you_**=per_mit (verb)

b. Here register shifts occurs pursuant to the particular inherent **pitches** of personal pronouns.

¯**my**_per¯mit (noun) vs. ¯=**our**¯=per_=mit (noun)
I¯per**mit** (verb) vs. ¯=you¯=per¯**mit** (verb)

c. Here changes occur according to stress and to choice of personal pronoun.

¯**I_**think¯so vs. _I ¯**think**_so
_you¯think_so vs. ¯you_**think**¯so

5.6 Multisyllabic segments

Pitch assignments for “permit” (noun) alternate here as determined by lexical and stress variations. The noun “permit”, which when unattached ends with low pitch, alternates that pitch with high as it moves further along the cymatic base line. Stress indicated by bold type.

_I¯**have**_the¯per_mit
¯I_**don’t**¯have=the_per¯mit
_I¯**still**_don’t¯have_the¯per_mit
¯and_I¯**still**_don’t¯have=the_per¯mit

5.7 Shift occurring in segments with augmented number of words

Here the pitches in ultimate syllables alternate as the number of syllables is augmented. Primary stress is in bold type.

with¯out**per**¯mit
_and¯with_out¯**per**_mit
_and¯with_out=a_per¯mit
_and¯with_out=a¯le_gal¯per_mit
the¯state=of¯Wis=**con**¯=sin
the¯great=state=of¯Wis=**con**_sin

¯**eat**_your¯food
_**don't**¯eat=your_food
o=pen¯=the**book**
¯please=o¯=pen =the¯**book**

6. SYLLABIC PITCH IN PHONOLOGY

6.1 Newly coined words not sanctioned by purists, include "outage", which combines English and French elements and is composed of an adverb with an abstract noun suffix. Nevertheless it has been adopted being cymatically acceptable, whereas possible alternates are not: cf. ¯out_age, vs. =pow_er _out¯age, =pow_er¯=out, =pow_er=fail¯=ure. The use of "rock concert" (= rock¯con_cert) for a production quite antithetical to a classical "concert" has been espoused because it offers a better cymatic form than would alternates like =rock=show or =rock=per=for=mance or =rock=re=ci=tal. Similarly, words borrowed by Middle English from Old French, like "counterfeit" were adopted having advantage over likely English counterparts, cf. ¯coun=ter_feit (noun) vs. _fake_mo¯=ney, _false_mo¯=ney or =forged_mo¯=ney.

6.2 Acronyms

Acronyms are, likewise, created for **cymatic** fluency ending with final low pitch appropriate for nouns: =A¯B_C, ¯U=S_A, =C¯B_S, _I¯R_S, =N¯F_L, =NA_TO, ¯U=S=S_R,¯la_ser, ¯scu_ba, ¯ra_dar, =p¯d_f, zip, etc. "CBS", standing for "Columbia Broadcasting System" was not followed by the other systems "ABC" and "NBC", since while ¯A =B_C and ¯N=B_C are cymatically correct, ¯A_B¯S and ¯N_B¯S would not be.

6.3 Novel technical terms

Many technical words and phrases, such as recently coined computer terms, unlike historically evolved ones, often fail to follow the rule of optimal **cymatic** pattern, as do the following, most of which are low pitched pairs, e.g., _drop_down_list, _snap_chat, _band_width, _boot_up, _broad_band, _re_boot, _fire_wall, ¯start¯up, ¯geek¯fest, =text=speak. Still, with added articles or conjunctions and used in phrases these terms fall into cymatic mode: =the¯band_width, _with¯=broad_band, ¯do_a¯re_boot, ¯=start_a¯snap_chat.

64. Tongue twisters—an explanation

Papers on tongue twisters have treated them as speech errors due to articulatory and motor inadequacies, and have also applied them in speech improvement and in learning English as a foreign language. Ongoing research has not yet explained the phenomenon, cf. Corley, et al. (2011). To quote psycholinguist Stefanie Shattuck-Hufnagel on “untangling tongue twisters to look at speech planning patterns” on the radio broadcast “Science Friday” at WNYC (12/06/2013):

“Flatow: Why is it so hard for us to say some of those tongue twisters?

Shattuck-Hufnagel: Well, we have some idea of the answer to that question, but we certainly don't have a complete idea yet. There are two factors that we think about: One is, what are the sounds themselves? So there's something about th- and sh- that are particularly difficult to say in sequence and so she sells seashells or the sixth sick sheik of the six sixth sheep's sick.

Those kinds of twisters are particularly hard partly because of the sound, the particular sounds that are involved. But there's another reason why things are hard to say, and that is the pattern with which the sounds occur. So if you think of she sells seashells, the s/sh are at the beginnings of those words, are alternating in one pattern.

And the e/l of the rest of the word is alternating in the opposite pattern, and it's kind of like rubbing your stomach and patting your head at the same time. Your brain just doesn't seem to be able to handle two alternating patterns in the same utterance very well.” (https://www.sciencefriday.com/segments/speech-science-tongue-twisters-and-valley-girls/#segment-transcript)

In cymatic terms tongue twisters are accounted for more briefly as imperfect DSP distributions. The ideal cymatic form is a perfect wave, and is thus properly pronounceable, i.e., _ = ¯ = _ = ¯ = _ , but in contrast tongue twisters are characterized by non cyclic undulations, lack of high pitched syllables, disarray of pitch sequencing, adjacent iterations of the same (or modified version of the) pitch, all of which interfere with fluid articulation. The dearth of high pitched segments brings absence of stresses which would serve to punctuate speech respiration.

Two samples from the “1st International Collection of Tongue Twisters / www.tongue-twister.net/en.htm” (© 1996-2018 by Mr. Twister) clearly exhibit that the difficulty in articulating them comes from uniformly assigning variants of mid level pitch throughout the segments.

=Six_=sick¯=hicks=nick_=six_=slick¯=bricks=with¯=picks_and¯=sticks

= _= ¯= = _= _= ¯= = ¯= _ ¯=

=If¯=Stu_=chews=shoes¯=should¯=Stu_=choose¯=shoes_he¯=chews?

Other tongue twisters consistently exhibit the same cymatic shortcomings:

¯=she_=sells=sea=shells=by_=the=sea=shore ¯= _= = = = _= = =

¯=three_=short_=sword¯=sheaths ¯= _= _= ¯=

=this =is=a¯=zi=ther

=pre¯=shrunk_=silk¯=shirts

¯=he¯=threw¯=three¯=free¯=throws

¯which¯=witch¯=is¯which?

¯=snake¯=sneaks=to¯=see =a_=snack

_=I ¯=scream=you¯=scream

Tongue twisters can also manifest as slips of the tongue. In an example taken from Fromkin (ed. 1980) the acymatic high pitch in last syllable of the target phrase causes word exchange to supply a cymatically correct low pitch to end the phrase.

Target: a fifty pound =bag_of =dog¯food
Error: a fifty pound _dog_of¯bag_food

6.5 Enumerating sequences in English and other languages

Pitch levels for unit segments in recitative sequences are averaged centered at mid pitch, maintaining the relatively monotonous intonation typical of enumerations, but the levels are modified to high mid and low mid pitches to produce strings of alternating levels. For clarity the symbols used here are high and low and do not indicate that they are, in fact, modified high and low mid pitches.

¯a _b ¯c _d ¯e _f ¯g _h (Here the initial high allows series to be fluid), whereas starting with the second segment, as in _b ¯c _d ¯e _f ¯g _h ¯i the acymatically assigned initial low pitch causes air tract constriction at the eight syllable and further. The same case occurs if the pitch of “b” is changed to high because apparently the phonetic identity of the name of the letter was created to suit enumeration.

The cardinal numbers present a similar situation:
_one, ¯two, _three, ¯ four, _five, ¯six, se_ven,¯eight, _nine, ¯ten vs.
_two,¯three, _four, ¯five, _six, se¯ven, _eight, ¯nine, _ten, ele¯ven

Russian: о¯дин, _два, ¯три, четыр_е, ¯пять, _шесть, ¯семь, во_семь, дев¯ять, дес_ять

Spanish: u¯no, _dos, ¯tres, cua_tro, cin¯co, _seis, sie¯te, o_cho, nue¯ve, _diez

German: ¯eins, _zwei, ¯drei, _vier, ¯fünf, _sechs, sie¯ben, _acht, ¯neun, _zehn

It may be inferred that the alternating cymatic wave sequence is the primary natural articulative setting for enumeration and that words composed of the appropriate phonemes to produce the alternating pitch sequences are then secondarily coined and overlaid on the setting.

The order of numbers is fixed and possibly their lexical forms have been coined to cymatically fit the enumeration sequence. This is illustrative in Hungarian, where the “kettő”, the cardinal noun for “two” appears in recitation of numbers, cf. _egy, ket¯tő, há_rom, ¯négy, _öt, ¯hat, etc. But the quantifier form of “two” is “két”, as in ¯két_lovag (two knights) since otherwise it would yield a final high: _ket¯tő _=lo¯vag. Additionally, in enumeration it would produce three adjacent highs, i.e., ¯egy,¯ két, há,¯rom, _négy, ¯ öt, _hat, etc.

6.6 Chinese cardinal numerals

Apparently even in tonal Chinese the pitch pattern of enumeration closely parallels the pattern in non tonal languages like English. Mid pitch gradations (likely due to Chinese tonal qualities) are indicated here, as before, with symbol combinations. Translating the numerals from one to ten first in pinyin tonal Romanization yields "yī èr sān sì wǔ liù qī bā jiǔ shŕ" and these (indicating pitch level, and rise and fall) may be approximately rendered as ¯yi _er ¯san =sz _=wu _lyou ¯chi ¯=ba _chyou ¯shr). The wave form yields ¯ _ ¯ = _= _ ¯ ¯= _ ¯

6.7 Enumeration of names and words

This itemization sequence of names or words in a row displays the same pattern as do the alphabet and numerals.

Ri¯chard, _Steve, ¯Tom, Alon_zo, ¯Carl, Ha_ssan, New¯ton, Ein_stein

foot¯ball, _car, tro¯pics, _book, book¯worm, fire_man, tung¯sten, car_bon

Neglecting this pitch ordering reduces fluidity of enumeration.

6.8 Register shift in ordered sequences

If an ordered itemization is started on the second member, shifting the lexical sequence one step down along the wave, the enumerative articulation of numbers or of the alphabet will become hindered after the first or second iteration of the sequence; syllabic pitches will no longer match their places in the cymatic cycles. In enumerations moving the initial step to the second one is analogous to register shifting in sequential logic circuits. This topic may be referenced at:

https://study.com/academy/lesson/registers-shift-registers-definition-function-examples.html

https://circuitdigest.com/tutorial/what-is-shift-register-types-applications/

6.9 Alphabetical order

Ideal cymatic sequencing in recitation, incantations, counting out in games, and in memorization makes them easy to learn, remember and recite. When incorrectly started with the second member the procedure suffers a degree of breathing constriction. The cymatically arranged form may have been a factor in inventing and shaping the order of the alphabet and the lexical forms of numbers. Likely for this reason the alphabetic order had changed as it moved from its Semitic source to the Indo-European speech environment.

In most Western languages the order of the alphabet has remain unchanged from its Latin form, but Latin was already altered when borrowed from Greek, while Russian adopted it with some alterations. Greek itself had also moved from its Semitic source, where differences also exist between Hebrew and Arabic. Cf. English a b c d e f g h i j k…; Greek a b g d e z h th i k...; Russian a b v g d e ë zh z i y k…; Hebrew a b g d h w z ḥ ṭ y k l…; Arabic a b t j ḥ kh d r z s sh…; The Sanskrit version k kh g gh ṇ c ch j jh ñ…, native to a quite different articulating system offers strong contrasts. These variations may all be products of adherence to cymatic fluency.

The order of letters of alphabet have been studied in connection with short term memory. (Gregory 1987) states that SKLRN is more readily remembered than BVTGP. Presenting this as DSA makes this fact credible as a matter of imprinting articulative fluency: ¯S=K_L_=R¯N vs. _B_=V_T_=G_P, where the former is a **cymatic** articulation, while the latter is low and mid low pitched throughout and therefore impedes the air flow.

6.10 High pitch final cadence in questions

"...It is often somewhat naively assumed that all questions end on a rising pitch, but the situation is certainly more complex than this.

yes/no question: *Would you like some ↗ coffee?*

alternative question: *Would you like ↗ tea or ↘ coffee?*"

(source: 25. Functions of Intonation in http://martinweisser.org/courses/phonetics/supra/intonation.html)

Questions typically end on high pitch, but there are exceptions that have so far not received explanation. This issue is clarified by applying DSA, namely that due to adding the word "or" the pitch distribution of the segment shifts resulting in a low pitched final syllable. The **cymatic** rule supersedes the necessity of raised pitch expected in queries.

¯=Would =you ¯=like =some ¯tea?
¯=Would =you ¯=like =some ¯tea =or ¯co_ffee?

6.11 Cymatic signature of parts of speech

The pitch of final syllables in verbs is high and low in nouns. Pronouns, adjectives, adverbs, conjunctions employ the mid pitch level.

The contrast in this aspect between verbs and nouns has been noted, as in verb per¯mit and noun per_mit (Ladd 2008), however, the notion was not explored to show that this is not merely a matter of intonation, but a mark of entire grammatical classes. For example:

Verbs:
=per¯mit
¯solve
¯rent
¯make
_de¯ter
=in¯vent
=e¯vade
¯ship
=dis¯guise

Nouns
=per_mit
¯pan_cake
_ad
_=su_pper
_ship
=gri_mace
=po_wer
=dis_guise

Pronouns
¯I
¯=you
_=he
_=she

Adjectives
=slow
=ripe
=quick
=a¯ma=zing
_=ra¯=pid
-blu=ish
¯=in=tent
¯=straight

Adverbs
=fast
¯quick=ly
¯=of=ten
_al=ways
_=there
¯care¯=ful=ly
=slow=ly
¯=a=broad

Conjunctions
=and
=or
_=be=cause
=than
=but
=since

6.12 Foreign nouns used in English

The pitch assignments of lexical and grammatical DSP signatures are not necessarily **absolute** highs, mids and lows, because the phonetic content of the syllable contributes to the vocalic quality of the nucleus. At the focus and resolution level of this paper these contextual inputs are indicated only when significant. Such instances occur in pitch modulations applied to the characteristic final syllabic **low** pitch of English nouns taken directly from Latin, Greek, French, Italian, etc., and only when these are pronounced within English phonetics. Here final pitches are altered to varying degrees: the mid low pitch of the noun cen=_sus is not especially notable while the pitch of auro¯=_ra combining all three pitches is more obstructive to articulation. The latter occurrence of merged pitches is frequent due to foreign phonetic sources which do not well suit English articulation. Identifying such pitches tend to be more difficult. The DSP patterns shown below refer only to isolated words; in phrases and in ongoing speech the phonetic environment modulates their opposition to articulation fluency.

French

apére¯_tif
pa=_nache
camou¯=_flage
en¯=_voy
para¯_chute
restau¯=_rant
de=_bacle
de¯=_tour
renai¯_ssance
bu¯=_reau

Russian

sput¯=_nik
gu¯=_lag
vod¯=_ka
tai¯=_ga
po=_grom
bolshe¯_vik

Greek

criteri¯_on
phenome=_noncri¯_sis
diagno=_sis
ellip¯_sis
hypothe¯_sis
mara=_thon
phobi¯=_a

Latin

al¯=ga
stra¯=tum
lar=_va
foe=_tus
mini¯_mum
si¯=_nus
nucle¯_us
modi=_cum
vi¯=_rus
minuti¯=_a

Italian

ari¯=_a
graffi=_to
libre¯=_tto
virtuo¯_so
bra=_vo
sopra=_no
pati=_na
tempe=_ra

7. HETERONYMS

7.1 Pitch variation in heteronyms

Pitch placement contrasting between heteronyms that are alternately nouns or verbs, as ¯per=mit (noun) vs. =per¯mit (verb) were in the past analyzed only in connection with stress and intonational emphasis, captioning the difference as “pitch realization for words *permit* (noun) and *permit* (verb) in citation form” (Ladd, 2008). However, such examination can be considerably extended in terms of pitch when intonation is disregarded. Cymatic pitch assignment of last syllables of parts of speech, and of grammatical and lexical aspects of words can elemental functions in word formation.

7.2 Heteronyms used as either nouns or verbs

In monosyllabic and bisyllabic heteronyms the exchange of pitch within a syllable or between syllables changes the same words into a noun or into a verb. Final syllable DSP for nouns is low and high for verbs.

noun	**verb**	**noun**	**verb**
_aim	¯aim	¯=in_sult	_=in¯sult
_knock	¯knock	=a¯=ban_don	_=a=ban¯don
_fight	¯fight	=sub¯sti_tute	_sub=sti¯tute
_dream	¯dream	_do¯=cu_ment	¯=do_cu¯ment
¯=la_bel	_=lab¯el	=te¯=le_phone	=te_=le¯phone
¯=sta_ple	_=sta¯ple	=pho¯=to_graph	=pho_to¯graph
¯=re_ject	_=re¯ject	=co¯=mmi_ssion	=co_=mmi¯ssion

Some trisyllabic heteronyms with alternate noun/verb function are exceptional in that the pitch of their final syllables is the same (stress is bold type):

=**re**¯gis_ter (noun) =**re**¯=gis¯ter (verb)
=po¯**si**_tion =po¯=**si**¯tion
¯=**ri**=di_cule _=**ri**=di¯cule

7.3 Role of last syllable in differentiating heteronyms

The pitch of last syllable in grammatically contrastive homophones determines pitch mapping. In bisyllabic homonyms such as ¯=per_mit (noun) and _=per¯mit (verb) the difference seems to be a mere exchange of pitches between the two syllables. Trisyllabic words with contrasting grammatical functions, however, show that it is definitely the final syllable that carries the signature of the part of speech.

=a¯=ban_don (noun)
_=a=ban¯don (verb)

=te¯=le_phone
=te_=le¯phone

=co¯=mmi_ssion
=co_=mmi¯ssion

_do¯=cu_ment
¯=do_cu¯ment

=pho¯=to_graph
=pho_to¯graph

=sub¯sti_tute
_sub=sti¯tute

8. PITCH IN GRAMMAR OF ENGLISH AND OTHER LANGUAGES

8.1 English irregular plurals

Formation of the irregular plural in English is complex. There are several types of plural endings such as those varying between /s/ or /z/ suffixes, depending on whether the words have voiced or voiceless final consonant or with ending in vowels. Others lack the plural form, such as “sheep” or “fish”, or else undergo internal vowel change as “tooth/teeth”, “man/men” or “goose/geese”. Some like “half/halves” change their voicing of the singular before adding /z/ for the plural while others form plurals with “-en”, as “children” or “oxen”. Words borrowed from Latin or Greek often use the plurals of those languages, and these are cymatically workable in English.

A less complicated categorization of plurals is available using DSA parameters. Namely, the appropriate plural suffix allows the noun in question to end with final syllabic low pitch inherent in nouns, while the incorrect one will result in a high mid. It may be inferred that DSP played a role in forming irregular plurals. The low of the singular form is partly preserved in the plural but it is slightly raised.

For clarity this is not indicated in the samples below which serve to contrast DSP in correct vs. incorrect plural forms.

ropes: /_roʊps/ vs. /¯=roʊpz/
gills: /_gɪlz/ vs. /¯=gɪls/
books: /_bʊks/ vs. /¯=bʊkz/
crumbs: /_krʌmz/ vs. /¯=krʌms/
potatoes: /pəteɪ_toʊz/ vs. /pəteɪ¯=toʊs/
plows: /_plaʊz / vs. /¯plaʊs/
cars: /_karz/ vs. /¯kars/
shoes: /ʃu:z/ vs. /¯ʃu:s/

child/children: /tʃɪld_ɹən/ vs. /¯=tʃaɪldz/
goose/geese: /_gi:s/ vs. /gu¯=səz/

ox/oxen: /ɑk_sən/ vs. /ɑk¯=səz/
mouse: /_maɪs/ vs. /maʊ¯səz/

half/halves: /_hævz/ vs. /¯=hæfs/
staff/staves: /_steɪvz/ vs. /¯=stæfs/

fish/fish: /_fɪʃ/ vs. /¯=fɪʃz/
tooth/teeth: /_tuθ/ vs. /¯=tuθs/
man/men: /_mæn/ vs. /¯=mænz/
sheep: /_ʃi:p/ vs. /=ʃi:ps/

8.2 Historical cymatic option for third person suffix /-s/ or /-z/

Modern English lacks personal endings for verbs except the third person singular “-s”. This can be shown as the likely result of optimal cymatic pitch formatting, cf. _I¯swim; _you¯=swim, in which cases final high and mid high pitches appropriately pronounceable. But _he/she/it _=swim or =he/she/it ¯=go results in a final mid low or mid high syllabic pitch, not in an expected low, and these variants constrict the air tract. The problem is solved by suffixing an “-s” surviving from the earlier “-eth” to yield final low pitch: _he/she/it_swims.

Reversing the historical development shows that as long as in the phrase “hē singeth” the pronoun is pronounced as the Old English /he:/ and not as the modern /hi:/ then the correct mid pitch occurs in the last syllable. If the old version ends with /-s/ the track is constricted, and if the modern one ends with /-eth/ the same occurs. Thus when the fronting and narrowing of /e/ took place the suffix also needed transformation. Cf. Modern English = he _sings vs. =he ¯sing¯eth.

8.3 Option for voiced or voiceless third person singular suffix

The variance of the **third person singular suffix** between /s/ and /z/ replicates that of the noun plurals, aiming to maintain the correct cymatic form. The incorrect suffix fuses all three pitches as it locks the tongue and blocks airflow.

pertains: /=pɝ_¯teɪnz/ vs. /=pɝ_=¯teɪns/
takes: /¯teɪks/ vs. g/_=¯teɪkz/
swims: /¯swɪmz/ vs. /_=¯swɪms/
paints: /¯peɪnts/ vs. /_=¯peɪntz/

8.4 Use of auxiliary "do" in negative sentences

The negative of =I¯read without the historically adopted insertion of "do", but rather using the negative particle "no" or "not", as is common in other languages, would give =I_not_read, an acymatic pitch sequence. The problem is averted with an inserted "do": =I_do=not¯read.
This solution was also applied to interrogatives. Instead of ending with a high pitch syllable typical of questions, without the insertion of "do" we would have ¯read_you? However, ¯do_you¯read? provides the correct wave format.

8.5 Oblique pronouns

There is common use of oblique case for personal pronouns in place of grammatically correct nominal case and this provides preferable finalizing phrase cadence.
=it¯is_me vs. =it_is¯I
=it's_me vs. =it's¯I
=it=is_her vs. =it_is¯she
=it=is_him vs. =it_is¯he

8.6 Partitives

Insertion of partitives in English and other languages ensures correct syllabic pitch in appropriate phrases.
¯give=me=some_bread vs. ¯give=me¯bread
¯drink=a_=glass=of¯=wa_ter vs. ¯drink=wa¯ter
¯j'ai=du_pain vs. =j'ai=pain (French "I have bread")
=ho¯del=pa_ne vs. =ho=pa=ne (Italian "I have bread")

8.7 Prefix options

Choice of optimal pitch determines selection of available prefixes since last syllable pitch must be low for nouns and mid for adjectives. Thus, English words borrowed from Latin may choose between either English or Latinate prefixes.

=un_de¯ci=ded vs. ¯in_de=ci¯ded
_in=di_=fe_rrence vs. =un_di=fe¯rrence
=in¯com_=pe_tence vs. =un¯com=pe¯tence
=un¯=con_=tes=ted vs. ¯in_=con¯=tes¯=ted
(Even though the first alternative below is in use, neither choice offers fluid articulation:
=un_con¯sti_tu=tio¯=nal vs. =in¯con¯sti_tu=tio¯=nal)

Native English words can take Latin prefixes rather than English ones in order to fit correct cymatic format.

=dis¯guise (verb) vs. _un_guise
=dis¯=robe vs. _un_robe
¯in=ter=min¯gle vs. =be_tween=min_gle
=dis_grun=tled vs. _=un¯=grun_=tled
=dis¯=band vs. _un_band
=dis¯trust vs. =un_trust

8.8 Definite article gender

In the German, French and Modern Greek examples below the incorrect article gender produces undesirable **acymatic** pitch sequences. Thus, the use of appropriate gender can be physiologically acquired by child learning the language.

=der ¯An_fang vs. ¯die =An¯fang or =das¯=An¯fang
=der¯Stra_sse vs. die_Stra¯=sse or =das_Stra¯=sse
=das_Weib vs. =der /Weib
=die ¯Span_nung vs. =das_Span¯nung
=le _chien vs. _la ¯chien
=la ¯pa=ti_ence vs. =le ¯pa=ti¯ence
=le ¯mar_teau vs. =la =mar ¯teau
η γέφυρα (bridge) =i¯ye=fi_ra vs. =o_ye=fi¯ra or _to¯=ye¯=fi=ra
ο σκορπιός (scorpion) =o=skor¯=pi_os vs. ¯i =skor¯=pi ¯os or _to =skor¯=pi ¯os

Note that the neuter “mare” (“sea”) of Latin became the feminine “la mer” (=la_mer vs. =le¯mer) in French while Italian preferred the masculine “il mare” (¯il=ma_re vs. _la_ma¯re) in order to preserve cymatic order.

8.9 Identifying stress in languages with free stress

In languages with free stress a comparison of possible pitch placements finds the correct stress. In the case of Russian nouns below, knowing that nouns end with low final syllables and adverbs with mid selects the correct stressed syllables. Bold type indicates stress.

колóда (“enough”) =kɐ_=**lo=**dɐ vs. _**ka** =lo¯=dɐ or ¯=kɐ =lo¯**da**
фáбрика (“factory”) _**fab**¯rʲi_kɐ vs. =fɐb¯**rʲi**¯=kɐ or =fɐb¯rʲi¯**ka**
óтпуск (“vacation”) =_**ot**_pusk vs. =ot¯**pusk**
разговóр (“conversation”) =раз_=го_**вор** vs. =раз¯**го**¯=вор

8.10 Vowel harmony in Hungarian

Vowel harmony which exists in certain languages constrains the choice of front vs. back vowels that can occur together in a word. This process has been extensively categorized, but not yet explained. There are two aspects to this function, one of which involves pitch, and is presented here for Hungarian. The inappropriate suffix noticeably impedes speech flow when it acymatically assigns high pitch to the last syllable which, being adverbial should be mid pitched. This is one explanation for the process, the other one not presented here is physiological.

=ke¯zem=ben vs. =ke_zem¯ban (“in my hand” (kezem=my hand, ban/ben= in)
=zi_va¯=tar=ban vs. =zi_va_=tar¯ben (“in the rainstorm”/ zivatar=rainstorm, ban/ben=in)
=fo¯lyó=hoz vs. =fo¯lyó¯hez (“to the river” / folyó=river, -hoz/hez=to)

8.11 Rhotacism in Latin

Latin rhotacism, the change of intervocalic “s” to “r”, has received no better explanation than being a historical phonetic change, cf. (Roberts 2012). However, pitch allocation according to DSA offers a more credible explanation. In these examples rhotacism generates the appropriate low mid final pitch (_=) expected of nouns in the genitive singular and plural.

Regular nouns:
=stel_la (nominative sg.), =stel_=lae (genitive sg.)
=mu=¯li_er, =mu_li¯er_=ris
Rhotacized nouns:
=mu_nus (nominative), =mu=ne_=ris (genitive singular) vs. =mu=ne¯=sis; (=mu_nus is classed as an r-stem noun, which should read “munur” but this would produce two adjacent highs: ¯mu¯nur)
=ge_nus, =ge¯ne_=ris vs. =ge_ne¯=sis
=ve_nus, =ve¯ne_=ris vs. ¯ve_ne¯=sis
=stel_la (nominative), =stel¯la_=rum (genitive pl.) vs. ¯stel_la¯=sum
=men_sa, =men¯sa_=rum vs. =men_sa¯=sum

8.12 Determining vowel length in Latin

Vowel length which is not indicated in Latin except in dictionaries or textbooks can be determined through DSA, because appropriate cymatic form is produced only when the correct syllable is made long.

The examples below cover verbs of the first person singular in active voice, the first person singular of deponent verbs, as well as singular nouns in the nominative case. Other forms are not covered here. The correct final DSP for verbs is high and low for nouns. Long vowels are marked with macron (¯), short ones are unmarked and stress is in bold type.

Nouns

baculum (“stick”) **ba**cu_lum vs. **bā**cu¯lum or ba**cū_**¯lum

tempestas (“season, storm”) **tem**pes_tas vs. **tēm**pes¯tas or **tem**pēs¯_tas

pīleus (“felt cap”) **pī**le_us vs. **pi**le¯us

rursus (“back”) **rur_**sus vs. **rūr**¯sus

tessera (“mosaic piece”) **tess**e_ra vs. **te**ssē_¯ra

tribus (“tribe”) **tri_**bus vs. **trī**¯bus

mālum (“apple”) **mā**_lum vs. **ma**¯lums

Verbs

moneō (“I warn”) **mo**ne¯ō vs. mo**nē**_ō

dē**pen**deō (“I hang down”) dē**pen**de¯ō vs. de**pen**de_ō

lābor (“I slip”) **lā**¯bor vs. **la=**¯bor

fungor (“I fulfill”) **fun**¯gor vs. **fūn**_gor

con**clū**dō (“I enclose”) con**clū**¯dō vs. con**clu**_=dō

con**ci**piō (“I hold”) con**ci**pi¯ō vs. con**cī**pi_=ō

8.13 Vowel weakening in Latin verbs

In certain Latin verbs vowel weakening occurs when adding a prefix. The standard explanation commits this change to an earlier initial stress in Latin, which later reverted back to the penultimate. This hypothesis is without any basis. Cymatic pitch assignment according to DSA explains it without a hypothesis for stress alterations; the vowel weakening merely changes the last syllable’s low pitch to a high inherent in verbs. Without the process occurring in these instances the verb would have the wrong cadence accompanied by restricted articulation. The weakened vowel appears in bold type:

=scan¯do becomes =de=sc**e**n¯do vs. =de_sc**a**n_do;
=tan¯go, =con_t**i**n¯go vs. = con¯tan_go
=clau¯do, =dis_cl**u**¯do vs. =dis_clau¯do
=sa_pi¯o, Eng. =in¯si=p**i**_ent vs. =in_sa_pi=ent
=ca=pi¯o, =in=c**i**_pi¯o vs. =in_ca_pi=o

8.14 Latin verbal stem modifications in the third conjugation

The Latin third conjugation verbal stems of the present active first person end directly with a consonant (tĕg-ō *“I cover”*), whereas in the second and fourth conjugations these end in -e and -i before attaching the personal endings, (mon-e-ō “I warn”; aud-i-ō “I hear”). Grammars term these -ē stems and -ī stems, and go no further. However, cymatic analysis shows the phonologically generated origin of such stem attachments. Without adding a vowel to the stem the final syllable of the present first person active verb would not possess the high pitch required. E.g.,

2nd conjugation: mone¯ ō vs. mon_ō, dēlē¯ō vs. dēl_o, time¯ō vs. tim_ ō

4th conjugation: audi¯ō vs. aud_ō, veni¯ō vs. ven_ō, sali¯ ō vs. sal_ō

Without the attachment of -ē and -ī to the verbal root its pronunciation is obstructed, whereas the vowels added to the stem enable fluid articulation.

9. LEXICOLOGICAL INSTANCES OF CYMATICS

9.1 Filler words

Filler words and phrases like “man”, “you know”, “totally”, “like” or “if you will” are intuitive tools for inserting low pitched syllables in order to permit unobstructed **cymatic** undulation. Another role for fillers is to lengthen phrases to optimize the breathing cycle. Another role for fillers is to elongate phrases to optimize the size of the speech breathing cycle. As pronunciation historically evolves through time phrasing often needs to change, cf. the currently growing use of the interposed “like”.

=o¯kay_man vs. =o=_kay

¯=I’m...(pause) vs. ¯=I’m_like… (pause)

¯I’m¯co_=ming¯=o¯=ver vs. ¯I’m=like_co¯ming =o_ver

Certain word combination are adopted without a good cause other than a cymatic one, e.g., using “virgin olive oil” when “olive oil” would be sufficient except for its ending with wrong noun pitch: virgin olive _oil vs. olive ¯=oil

9.2 Commercial articulative approach and avoidance

The standardized adoption of adding “ninety-nine” to prices as in =five_nine¯ty_nine or ¯fif=teen_=nine¯ty_nine results in a segment carrying the correct DSP noun cadence and it appears to reduce the level of concern for paying the price. Alternate configurations such as =ten¯=do¯=llars or =ten _=nine¯ty¯=five, etc., do not bring the same results. The psychological effect of final syllable low pitch is important in coining commercial nomenclature for brand, product and drug names as discussed in (Topolinski et al. 2014) and (Godinho et al. 2018), but without the application of DSA.

9.3 Word order in noun pairs

Ordering in paired nouns aims to yield correct final syllable pitch assignments, which is low for the nouns sampled below. Reversing the order produces acymatic segments and thus negates their articulative fluency and appeal.

¯ ba=con=and_eggs vs. =eggs_and=ba ¯con

=be¯fore=and¯af_ter vs. _af=ter_and=be_fore

=hea¯ven=and_earth vs. =earth=and=hea=ven

¯Jack_and_Jill vs. = Jill_and_=Jack

_salt =and ¯pe_pper vs. =pe_pper=and¯salt

_ulna =and ¯radi_us vs. =ra¯di=us =and _ul¯na
¯thun_der=and ¯light_ning vs. ¯light=ning=and_thun¯der
=the=may_ors=and_go¯ver_nors vs. =the_go=ver=nors=and=may¯ors
¯man=and_wife   vs.   _=wife=and¯=man
¯bride=and_groom   vs. _=groom=and¯=bride
¯peace=and=qui_et   vs.   _=quiet=and¯=peace
¯hustle=and_bustle
=A¯dam=and_Eve
¯pea=ches=and_cream
=clothes_don't¯make=the_man
=it¯cost=an=_arm=and¯=a_leg
¯think_=out¯=side=the_box

9.4 Choice of alternates

The lexical role of DSP is observable in choosing between available alternates. This can be shown in at least three examples: a) English demonym suffixes for city names, b) alternates between American and British words for the same object, and c) compound words.

a) English demonyms of cities, where one of six possible alternate suffixes (-ian, -an, ite, -ese, -er, -i) offers appropriate DSP for nouns:

Beijing_er vs. Beijing_=an or Beijini¯=an
Bosto_nian vs. Bosto¯ner or Bosto¯=nite
London_er vs. Londo¯=nan or Londoni¯=an
Misco_vite vs. Musco¯van or Muscovi¯an
Nankin_ese   vs. Nanjin¯=gan or Nanjing_=er
New Yor_ker vs. New York¯=an or New Yorki¯an
Palermi_tan vs. Palermi¯=an or Paler¯=man
Parisi_an vs. Paris¯er or Paris¯an
Tehran_i vs. Tehra_=ner or Tehrani_=an
Veneti_an vs. Veni¯cer or Veni¯cite
Veniti_an vs. Veni¯cer or Veni¯cite

b) American and British usage of different words for same object, where possible alternates are acymatic:

US pronunciation	UK pronunciation
gaso_line vs. pet¯=rol	pet_rol vs. gaso¯line
hand_bag vs. ¯purse	_purse vs. hand¯bag
apart_ment vs. ¯flat	_flat vs. apart¯ment
flag_pole vs. flag¯staff	flag_staff vs. flag¯pole

en_gine vs. mo¯tor   mo_tor vs. en¯gine
can_dy vs. ¯sweet   _sweet vs. candy
eleva_tor vs. ¯lift   _lift vs. eleva_=tor
_truck vs. lo¯=rry   lo_rry vs. ¯=truck
side_walk vs. pave_=men   pave_ment vs. side¯=walk
_trunk (of car) vs. _=boot   _boot vs. _=trunk
clo_set vs. ward¯=robe   ward_robe vs. clo¯=set
fau_cet vs. =tap   _tap vs. fau_=cet

c) Compound words in English where possible alternates are acymatic:

fairy _tale vs. fairy sto¯=ry
ghost _story vs. ghost _=tale
folk _tale vs. folk sto_=ry
sail _boat vs. sail _=ship
steam _boat vs. steam ¯=ship
fine _print vs. small ¯=print
hand _shake vs. shake _=hand
up_lift vs. lift¯_=up

10. SUMMARY

10.1 Two levels of pitch application

This paper shows that associated with ordinary **pitch intonation** there is **another** articulative **level**, that of **discrete** s**yllabic pitch (DSP)**. Each syllable contains an innate nuclear pitch, which in segments of syllables ideally construct a wave-shaped **cymatic** sequence, as do cycles of respiration. The paper has covered several aspects of DSP but that was only a small part of its wide ranging functions; for further research discrete syllabic pitch analysis offers an **ample** field.
Whether there is hierarchical ordering to these two levels it may be **stated** that the intonational and DSP levels work simultaneously and there appears to be no hierarchical order (cf. **4.16**). In physiological terms pitch in **intonation** is created by the unit tongue structure as a **whole**, whereas **DSP** pitch depends on the lingual location of the **prime mover** in each particular syllabic articulation. This location can be either in a) the three longitudinal layers, or in b) the three axial sections of the tongue.
It was stated that particular nuclear syllabic pitches are physiologically **assigned** to specific regions of the tongue. Thus, high pitch belongs to the tongue's superior layer in the tongue blade, while low pitch works with the lingual inferior layer in the tongue body. The mid pitch associates with the shared intervening layer or section.
DSP is ordinarily **masked** by articulation, by attenuation of syllabic borders and by the force of phonation (Brown, et al., 2009), and it can be best observed using the specific technique presented.

The cymatic **functions** of DSP were demonstrated in examples of **grammatical** formations (prefixes, def. article gender options, third person singular suffix in English, etc.) and in **lexical** contexts (word order, word formation, word coinage, serial enumeration, etc.).

English is the language mostly in focus, but the analysis also includes instances in a number of others. Besides presenting a base for a new field of research, familiarity with DSP wave patterns can assist in **studying** foreign languages, for example in giving automatic indication of stress placement, of correct genders, etc.

10.2 DSPs: grammar or cognition?

This paper covers DPS in terms of articulation, but it may be pointed out that cognition is involved at the same time. In section 6.11 dealing with DSP in distinguishing parts of speech cognition was definitely considered (though without stating so) because articulation and cognition of a segment are inseparable. Both emerge in the mind where cognition may precede articulation.

10.3 A question

The question arises as to how a mere three syllabic pitch levels can uniquely signify a variety of characteristics, such as indicators of part of speech, alphabetical order, definite article gender, prefix options, nominal vs. oblique pronouns, word order, the need for partitives and filler words, etc.

10.4 Permutations of pitch and lingual prime movers--primary and secondary presettings

The explanation is that through the permutations of combining the three pitch levels and nine lingual regions in which prime movers can arise a large number of **unique** grammatical and lexical indicators are available. The nine lingual regions are synthesized by intermixture of the three longitudinal and three axial divisions of the tongue as described in the **Appendix A**.

This system is hierarchical: any segment pronounced without reference to anything creates general frame tension setting of the speech mechanism. When a target is chosen the pitch of that specific grammatical or lexical objective is put in place. This is the **primary** configuration onto which **secondary**, modifying characteristics can be laid over. Thus, in enumeration the primary frame of the enumeration is first preset over which setting the sequence of letters, numbers, names, etc. is superimposed. In coining acronyms or in ordering words the final choices are those that optimally fit an initially preset ideal cymatic frame.

In vowel weakening the attenuated syllable(s) fit an initially preset ideal cymatic pattern, whereas without attenuation ideal undulation is not reached.

10.5 Simplicity in nature

Systems working with higher numbers of pitch, cf. Pike (1945), Pierrehumbert (1980) or Mertens (2001, 2013, 2014) and others, unlike Campinoe & Veronis (2001), and the present paper dealing with only three pitches, would not sufficiently touch on an interesting subject for investigation. Notably **three** pitches with secondary superimposed gradations suffice to systematically indicate lexical parts, grammatical factors and cognitive values each numbering over three elements. The general tendency of nature and evolution to prefer minimal components may account for this.

Several functions in oral organization employ no more than **three** categories or three factors. These include the phonemes (vowels, consonants, semivowels), articulation positions (front, central back; high, mid, low), the chief primary parts of speech (noun, pronoun, verb, adverb/adjective/conjunction). Going further into physiology, there are three horizontal intrinsic lingual muscles (superior longitudinal, tranverse-vertical, inferior longitudinal), three axial lingual regions (tip, blade, body), three salivary glands (lingual, sublingual, parotid), three oral stages in feeding: ingestion, mastication, swallowing (Hiiemae and Palmer 2003), three mandibular muscles (masseter, medial pterygoid, lateral pterygoid), three parts of tooth (crown, neck, root), three layers of the tooth (enamel, dentine, pulp), three muscles connecting jaw and hyoid bone (genioglossus, geniohyoid, mylohyoid), etc. It may be also considered that the most stable basic structural unit is the **truss**, consisting of three elements and that t**hree** interactive units are the components of **peristaltic** motion (Seok, et al., 2010).

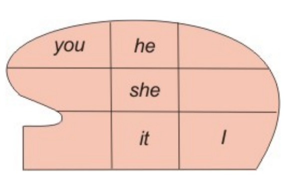
APPENDIX A. Cymatic marking of part of speech

1. There is a level of DSP distribution below the **cymatic** level described so far. Verbs were characterized by **high** final DSP but the discussion was applied to neutral entities maintained at what should be called **primary** cymatic level. In section **6.11** were shown the different DSPs of parts of speech (PoS) at such primary (base or neutral) level. But PoS's divide into grammatical categories, i.e., persons or tenses for verbs, number and possessive for nouns, and comparative degrees for adjectives, etc.

DSPs for these subclasses exist below the primary level as a secondary or *infracymati*c one. In **Part 4.** the divisions of the tongue were described as consisting of three horizontal and three axial regions. In practice these operate combined are mapped out in the form of a 3x3 cellular matrix otherwise known as the *vowel quadrilateral*.

However, this matrix plays an organic role in several other lingual functions, as in DSP labeling discussed in Part 4., and as here, in distinguishing pitch assignments at the secondary DSP level, where, just as cardinal vowels, DSPs of grammatical subdivisions fall into appropriate matricial cells.

Dealing in **6.11** with PoS's had already introduced **cognition** into the discussion since cognition is a fundamental component of language. At the **neutral primary cymatic** level the DSP of the first person singular pronoun "I" carries a **high** DSP and the second singular person "you" has high mid pitch. But as cognized entities these are mapped quite differently in the 3x3 matrix:
Cognition of the "I" as the idea of self assigns its DPS to the low back cell, whereas cognition of the DSP of "you" resides in the high front cell, and "he", "she" and "it" belong respectively, in the high, central and low cells of the mid/shared axial section.

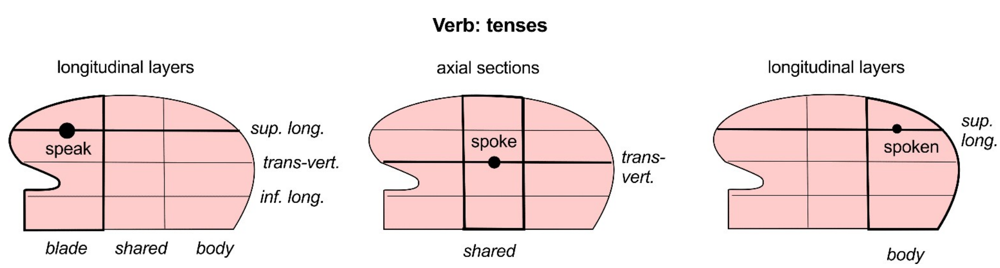


An efficient way to verify these assignments is not by producing the pronouns and then searching for the appropriate cells, but rather a) to first produce the 3x3 quadrilateral frame, and b) to then insert the syllabic nucleus of the pronoun in the prescribed cell, and c) to test by being able to readily perceive any other empty cell while maintaining the chosen pronoun's DSP anchored in its own cell. If the verification were to start with the pronoun, it would create its own frame overlaid on and obscuring the underlying 3x3 matrix. The following section offers more complete explanation of the secondary level DSP assignments of parts of speech.

1.1a The lingual mechanics underlying secondary grammatical DSP assignments is explained as follows. **Identifying** primary DSPs was described as a function of **either** the **three longitudinal** muscular layers, **or** of the **three axial** sections of the tongue. This means that the two modes can **exchange** roles in a manner similar to the alternating agency of either arm of a balance or of a see-saw. That is, the two configurations are **coactive** in an **agonist-antagonist** coupling; when one is the primary agent the other one is the secondary, or antagonist.

1.1b In a**gonist-antagonist** action either of the two elements interact and can alternately take the role of prime mover. This behavior exists in vertebrate limb locomotion, in segmental alternation in locomotion of fish, reptiles, worms and caterpillars, in peristaltic movement, in alternate potentials in cardiac action (Nolasco & Dahlen 1968), and so on. It also occurs in terrestrial respiration as inspiration vs. expiration, in consonant-vowel sequences, or in the cymatic pitch wave.
This function manages DSP **grammatical assignments**. Specifically, alternation occurs between the agonist-antagonist agency of **longitudinal** vs. **axial** lingual division in **grammatical** pitch assignments (**GPA**s) of final syllables. This scheme illustrated in the examples below.
In these diagrams the placements of bullets in longitudinal layers and axial sections are governed according to two aspects of the word: a) part of speech and b) hierarchical rank of primary mover. The hierarchical ranks of frames are ordered as:
Primary rank: verb present, noun singular, adjective positive
Secondary rank: verb past, noun plural, adjective comparative
Tertiary rank: verb perfect, noun possessive, adjective superlative
(adverb has only one rank)

1.2 Verb



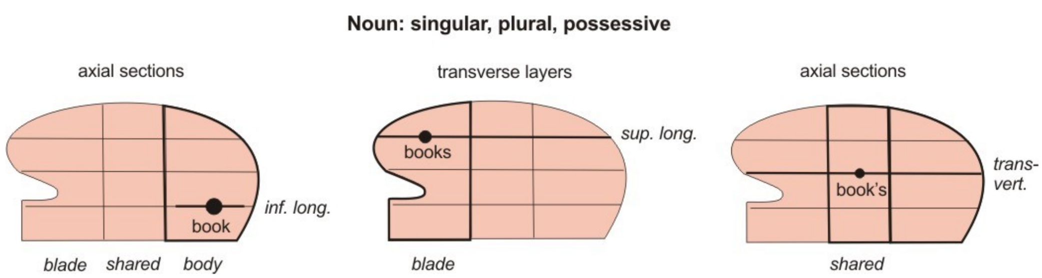
a. The innate high front GPA of the general or base form verb (without person, number and tense modifiers) is in the longitudinal layer, where it is the primary agent, while the secondary axial component is the antagonist. The primary frame function is indicated with large bullet.

b. For the past/preterite tense the GPA is secondarily superimposed on the base verb and performs alternation of prime agency from longitudinal to axial and its placement moves to the longitudinal line in the axial section.

c. The tertiary hierarchical frame of past participle executes another prime mover exchange arriving at the high back longitudinal position, in the axial back section. Thus in each step both the longitudinal and axial placements alternate.

d. The GPA of an unmodified non-conjugated verb or of a non-declined noun, etc., is the base frame on which the subframes of these grammatical modifications are superimposed according to order of hierarchical rank. The base form remains embedded in nested superimpositions. When a superimposed frame is lifted, the previous one(s) remains in place. The order of GPA superimpositions for English verbs is a) the base present tense form, b) the preterite, and c) the past participle.

1.3 Noun



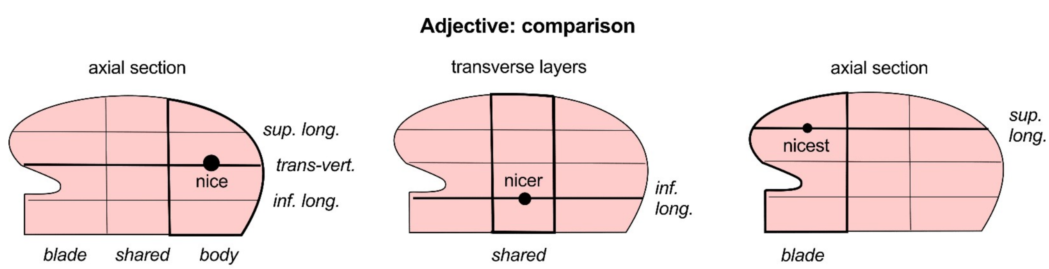
a. The singular noun GPA is at the low level of the axial back section, which is the primary agent.

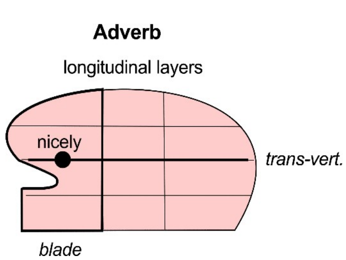
b. The plural noun GPA moves to the longitudinal high font, now being the secondary agent.

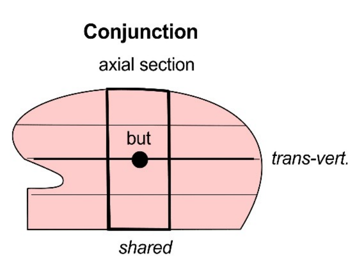
c. For the possessive the GPA once again takes mid axial agency and is located one the mid level line.

1.4 Adjective, adverb, conjunction

The positive adjectival GPA is axially primary, on the mid longitudinal line of the back axial section. The comparative position is low longitudinal in the shared axial section. The superlative once more is axial and is secondarily high longitudinal.







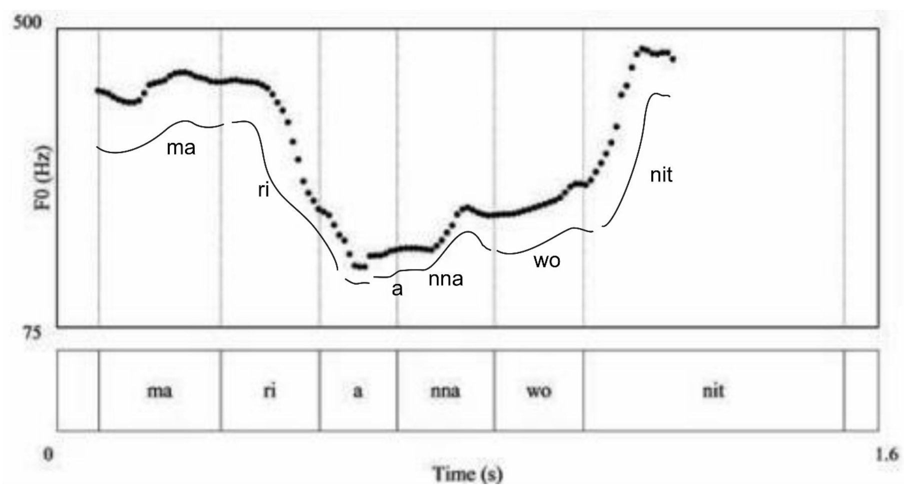
a. The GPA of adverbs is set at the primary axial mid pitch in the secondary front axial section.
b. The primary agency of conjunctions is longitudinal mid level and the secondary one as mid axial.

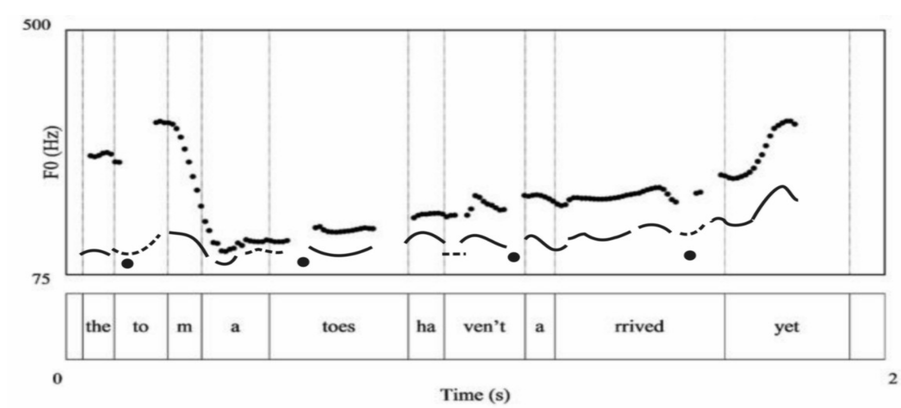
1.5 The ability of only three pitches, high, mid and low, to assign **unique** labels for eleven distinct configurations is evidenced by the fact that there are no identical duplicates in the diagrams above. If in some cases bullet anchors are in the same cell, they differ as parts of speech or in hierarchical rank. E.g., bullets for “speech” and “books” both appear in the blade section and on the superior longitudinal line, but one is of primary verb rank, while the other is a noun of secondary rank. “Speak” and “nicest” also share the same position, but contrast as parts of speech and hierarchical rank.

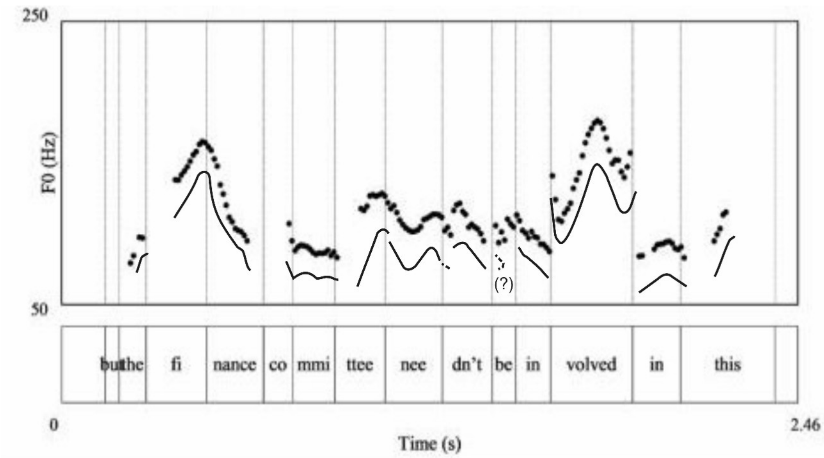
(to Editor: page break here, Appendix B. on next page. Break is necessary to avoid diagram place dislocations)

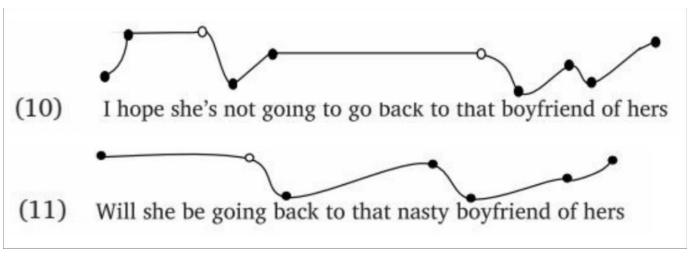
APPENDIX B.

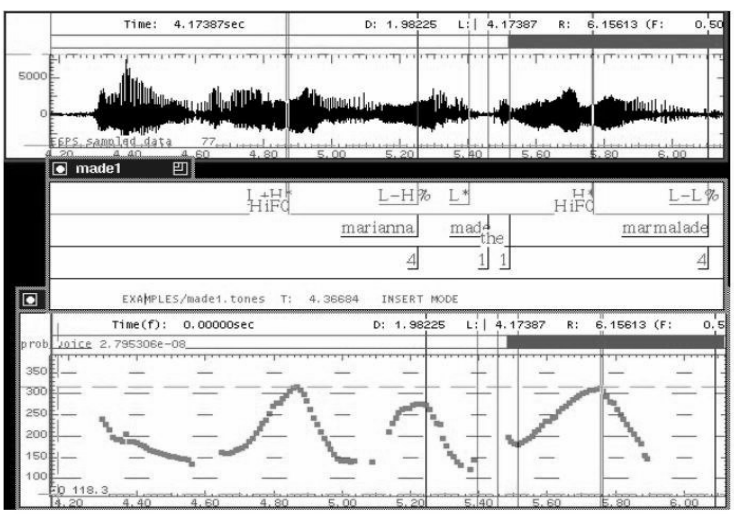
Interestingly, **cymatic** behavior is often discernible even in **normal** speech, although unless looked for, the pattern can elude notice. In Gussenhoven (2016) spectograms in his figs. 3.3a., 3.3b, 9.b. (starting from top) exhibit a nearly well ordered undulation of highs and lows. The syllabic pitch paths are not horizontally aligned since they appear at different fundamental frequency heights. Nevertheless, when redrawn in a more clear-cut way (thin lines) regular cymatic undulation of sequential highs and lows is observable. Imperfections in the wave form can occur due to the phonetic contents and boundaries of certain syllables. Syllables were inserted under wave segments in fig. 3.3a; bullets added in fig 9b. indicate stops. The individual wave phases in the line graphs in figs. 3.5/10 and 11 following are a mixture of segmental and syllabic units, but still exhibit an obvious wave pattern present even in intonation. The last example is from *Guidelines for ToBI Labelling* excerpted from http://www.speech.cs.cmu.edu/tobi/ToBI.1.html. Thus, **cymatism** can surface in **ongoing** speech.











EXAMPLE: Marianna made the marmalade.

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