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.

Highlights

- Discovery: a structured system of discrete syllabic pitches exists under articulation
- Discovery: categories of parts of speech possess unique syllabic pitch markings
- Discrete syllabic pitches function in historical development of grammar and words
- A specific novel methodology serves to identify discrete syllabic pitches
- Utilizing discrete syllabic pitches assists in learning English and second languages

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, syllabic pitch, intonation, 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 1967) with five, cited in (Hirst & DiCristo 2000), consisting of three absolute levels plus five modifiers which includes three relative levels and two iterative levels, c) (Campinoe and 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) and taken up in (Pierrehumbert 1980) and by (Beckman & Ayers 1994). 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 (cf. Section 1.6).

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 in (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" (Mertens 2014, Abstract). (Note: in the cited Mertens' pdf files pages are not numbered, except in [Mertens 2013]).

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." (Mertens 2004, Section 2, paragraph 3).

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." (Mertens 2014, Section 5.2). 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." (Mertens 2014, Abstract). 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 the following ways:

a) it 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) it 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. 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., =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¯sells, =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 Figure 1. shows taken from (Mertens 2013, p. 43).

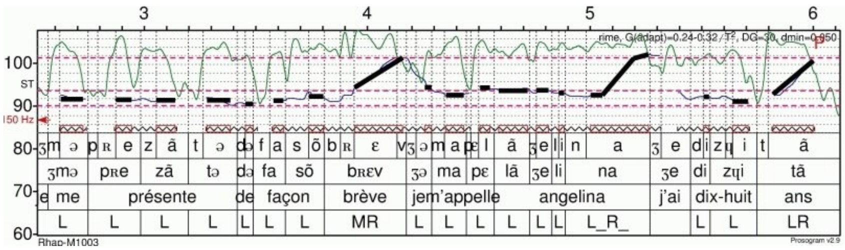


fig. 1 Non-discrete syllabic labeling in (Mertens 2013, p. 43)

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 chant, like any stretch of speech lacking minimal syllabic pitch variation. The distinct inherent pitches of these syllables, masked by intonation, are shown at Section 1.19 example 1.

Hence in Figure. 1 interference between syllables occurs, as a process termed “ambisyllabism” (Mertens 2014, Section 5.2) 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 broadly 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

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 (cf. Section 3.8).

2.3 Nuclear pitch

Nuclear 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 Section 4.6, Figure. 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 obtained pitch levels

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 to 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 in a t state 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 (Hiiemae and Palmer 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).

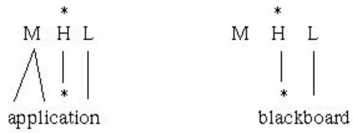
3.5 Control technique in whisper mode

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 with pitches labeled

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 (for labeling symbols refer to Section 1.6):
_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.
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 mentioned in Section 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 the monosyllabic word *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, either open or 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 neutralize any forces that impede the tongue and jaw configurations from landing in their syllabic nuclear pitch resting 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, Figure 2.

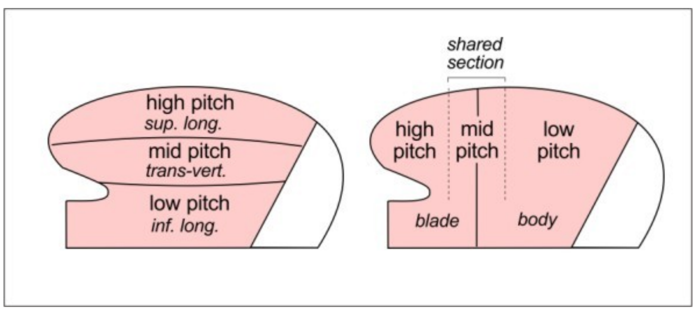


Figure. 2 Tongue regions for identifying DSPs

4.7 The jaw must be sufficiently relaxed to avoid its overpowering of tongue action (Gibbs and Messerman 1972), (Seurrier et al. 2012), and (Hiiemae and Palmer 2003).

4.8 As per examples above in Section 3.6 on 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

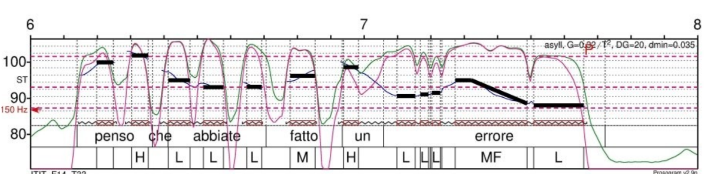
DSP of final syllable is the identifying mark in distinguishing between grammatical elements and between cognitively contrasting words, the latter discussed in manuscript prepared for submission by this author. Therefore, in most cases it is only the **final** syllable pitch that is significant and needs 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 Section 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 English verbs (produced without tense and person) the node will be in the **superior longitudina**l muscle layer, while for nouns (in the nominative singular) 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, o 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 Figure 4.



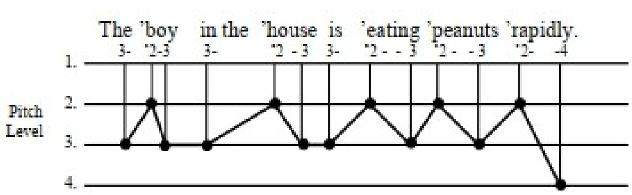


Figure 2.3: An intonation contour defined using primary contours.

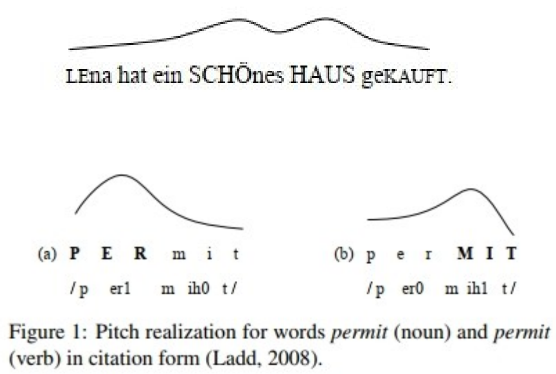
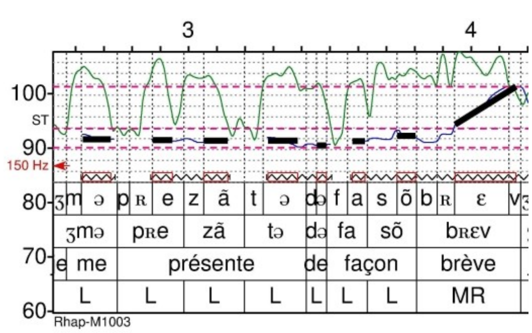


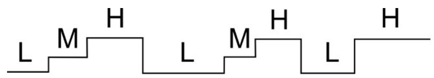
Figure 4. Examples of wave patterns exhibited in intonation [Sources from top down: (Mertens 2013), (Pike 1945), (Grice 2007), (Li 2018)]

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 easily 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, p. 43) 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:





_je=me¯pré_sente=de¯fa _çon¯brève

Figure 5. Cymatic analysis applied to automatic labeling in Figure. 1 in (Mertens 2013, p. 43)

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

Example 2.

Figure 6. Example of wave pattern in intonation, (Grice & Bauman 2007, Figure. 3)

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 2004, Figure 1) breaks a sequence into separate syllables to demonstrate **pitch contours**, his technique does not here exclude ambisyllabism and so discrete syllabic pitches are not detached from pitch levels of preceding and following syllables.

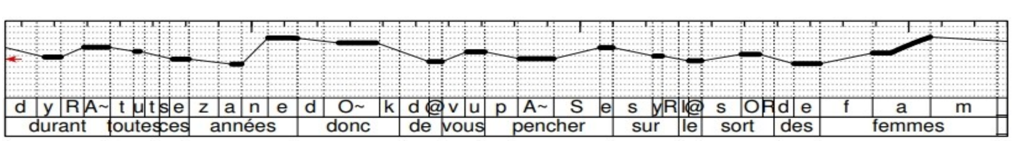
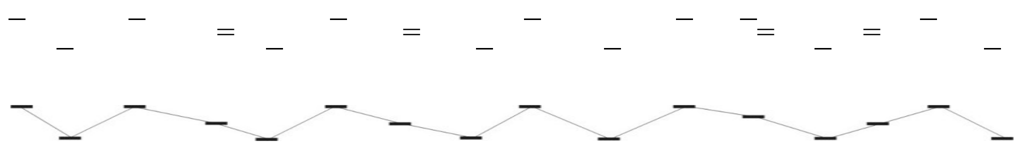


Figure 7. Ambisyllabism shown in automatic labeling (Mertens 2004, Figure.1)

In the intonation contour of this figure individual syllabic pitches show ambisyllabically caused compression. In comparing the pitch levels represented as 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. (Pike 1945, Section 2.3, Figure 1.):

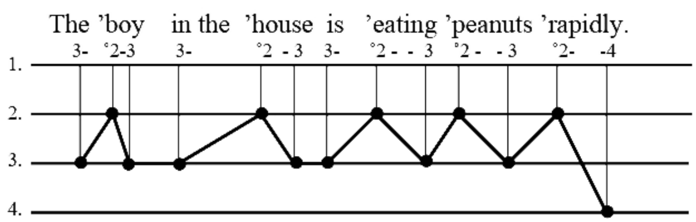


Figure 2.3: An intonation contour defined using primary contours.

Figure 8. Regular wave pattern observable in intonation contour

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

=The¯**boy**=in=the¯ **house**=is¯**ea**=ting¯**pea**=nuts¯**ra**=pid_ly (bold type indicates stress)

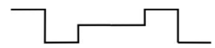
The same pitch sequence omitting text: = ¯ = = ¯ = ¯ = ¯ = ¯ = _

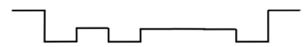
This sentence exemplifies a recognizable, though imperfect wave, intoned on the mid level, with a span of only mid to high pitches, and reaching a low only at the cadence of the sentence.

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 and efficient speaking 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* (Faulkner 1930):

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

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

2) from *The Shadow of the Torturer* (Wolfe 2021):

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

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

3) from *1984* by George Orwell (Orwell 1949):

=It_was=a¯bright=cold¯day=in¯Ap_=ril = _ = ¯ = ¯ = ¯ _=

b. A semi perfect sequence contains connected mid pitch subsegments and an insufficiency of low pitch cadences, a style which can occur in exclamatory prose, 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.

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

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 acymatic phrases ending at mid level hamper natural breathing pauses.

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

4.16 Are intonation and DSP hierarchically ordered levels?

DSA brings to light a level of speech generation that operates below that of intonation. Stating that DSP surface is <u>below</u> 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 in normal ongoing speech.

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 at the same time and so there is an initial step where both functions are already set for running the entire segment. Apparently intonation and DSP are a 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. However, in DSA normal intonation is absent and so it is not an ongoing speech process.

4.17 The cymatic wave format as a rule

DSA shows that speech segments, under normal intonation, are produced with optimal articulative efficiency proceeding in a cyclically regular cymatic ordering. High and low pitches alternate typically going through intervening mid levels. Wave nature of a sequence is evidenced by the cyclic shift (or register shift, cf. Sections 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 and grammatical functioning. Ongoing speech automatically selects words and phrases and their order prior to enunciation—least for fluent speakers. One reason for this is that language has a learned collection of cymatically optional words and phrases which are automatically applied in speech. As cited in Section 2.4 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).

The requirement of ideal cymatic wave format can thus be assumed 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.

5. INHERENT SYLLABIC PITCH

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), _=set (noun), ¯set (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 examples are not always present 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*. Bold type indicates stress.

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. Stress is shown 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 usually 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.

6.4 Tongue twisters—an explanation

Analyses of 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" featured in the radio broadcast "Science Friday" (WNYC-FM 93.9 FM. Dec. 6, 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.

Through cymatic analysis tongue twisters are accounted far more aptly and briefly as being 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, dearth of fully 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 paucity of high pitched segments causes an 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 employing variants of mid level pitch throughout the segments and a scarcity of low pitches.

=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 1980) the acymatic high pitch in last syllable of the target phrase causes word exchange to supply a cymatically correct low pitch to cadence of 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

DSP levels for unit segments in recitative sequences are centered at mid pitch maintaining the monotone intonation in enumerations with discrete syllables, but the pitch 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. The mid pitch gradations (likely due to Chinese tonal system) are marked 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 shí" 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 is: ¯ _ ¯ = _= _ ¯ ¯= _ ¯

6.7 Enumeration of names and words

Discretely pronounced sequences of names or words displays the same pattern as do the alphabets and numerals. While all are nouns, individually with low final DSPs, here every other has a high final pitch:
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 alternation ordering reduces fluidity of enumeration.

6.8 Register shift in ordered sequences

If an ordered itemization is started on the second member (cf. 6.5), 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 established 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 passed through changes as it moved from its Semitic source to various Indo-European phonetic environments.

In most modern 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 different phonetic system offers strong contrast. 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 1996), 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, =gri_mace, =po_wer, _ship, =dis_guise
Pronouns: ¯I, ¯=you, _=he, _=she (“she” is slightly lower and retracted, not indicated by symbol)
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

Note**:** Pitch of words with negative connotation are modulated due to the factor of cognition. E.g., the innate low pitch of the noun *shark* is partially elevated as =_shark, and the innate high pitch of the verb *loose* becomes =¯loose. Such modifications occur in all words as a result of cognitive input.

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=_non, cri¯_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, defining the difference as “pitch realization for words *permit* (noun) and *permit* (verb) in citation form” (Ladd 1996). 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 perform elemental functions in word formation, cf. Table 1.

7.2 Heteronyms used as different parts of speech

Altering the pitch of a monosyllabic heteronym or of the final syllable of a polysyllabic one changes its identity as part of speech from noun to verb or from adjective to verb, as well as from noun to adjective.

noun	**verb**
_aim	¯aim
_knock	¯knock
_fight	¯fight
_dream	¯dream
¯=sta_ple	_=sta¯ple
¯=re_ject	_=re¯ject
¯=in_sult	_=in¯sult
=po¯si_tion	=po¯=si¯tion
adjective	**verb**
=close	¯close

=per=fect	=per¯fect
_=al¯=ter=nate	=al=ter¯nate
=de¯=li_=be=rate	=de¯=li_=be¯rate
noun	**adjective**
=pa_sty	¯=pa=sty
=mi_nute	_=mi=nute
¯=in_=va_lid	¯=in_=va=lid
_=au_gust	¯=au=gust

Table 1. Alternate syllabic pitches in heteronyms

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. Note: the initial DSPs of *permit* are more exactly labeled here than elsewhere in this paper.

=a¯=ban_don (noun) vs. _=a=ban¯don (verb), =te¯=le_phone (noun) vs. =te_=le¯phone (verb), =co¯=mmi_ssion (noun) vs. =co_=mmi¯ssion (verb), _do¯=cu_ment (noun) vs. ¯=do_cu¯ment (verb), =pho¯=to_graph (noun) vs. =pho_to¯graph (verb), =sub¯sti_tute (noun) vs._sub=sti¯tute (verb)

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/halve*s 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. In these cases the low of the singular form is 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/mice: /_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/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 are appropriately pronounceable. But _he/she/it _=swim or =he/she/it _=go result in a final mid low syllabic pitch, not in an expected high for verbs, and these variants constrict the air tract. The problem is solved by suffixing an *-s* evolved from the earlier *-eth* to yield final high 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 is ended with /-s/ the speech track is constricted, and if the modern one ends with /-eth/ the same occurs. Thus when the fronting and narrowing of the Old English /e/ took place the suffix also needed transformation. Cf. Modern English = he¯sings vs. =he =sing_eth.

8.3 Option for English voiced or voiceless third person singular suffix

The variance of the English 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.

takes: / ¯teɪks/ vs. /_=¯teɪkz/

paints: / ¯peɪnts/ vs. /_=¯peɪntz/

pertains: /=pɝ_¯teɪnz/ vs. /=pɝ_=¯teɪns/

swims: / ¯swɪmz/ vs. /_=¯swɪms/

8.4 Use of auxiliary "do" in negative sentences

The negative of =I¯read without the historically adopted insertion of *do*, but rather using only 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 with high for the verb. This solution was also applied to interrogatives. Instead of ending with a high pitch syllable typical of questions, without normal intonation and without the insertion of *do* we would =have_=you_read? or =have ¯read_you? However, ¯do_you¯read supplies the correct high final interrogative pitch.

8.5 Oblique pronouns

There is common use of oblique case for personal pronouns in place of grammatically correct nominal case and this practice provides preferable finalizing low pitch phrase cadence.

=it¯is_me   vs. =it_is¯I

=it's_me vs. =it's¯I

=it=is_her   vs. =it_is¯she

=it’s_us vs. =it’s¯we

=it’s_him vs. =it’s¯he

8.6 Partitives

Insertion of partitives in English and other languages ensures correct syllabic pitch sequence in appropriate phrases which means that nouns and phrases end with correct low pitch.

¯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.

_in=di_=fe_rrence (noun) vs. =un_di=fe¯rrence

=in¯com_=pe_tence (noun) vs.   =un¯com=pe¯tence

=un_de¯ci=ded (adjective) vs. ¯in_de=ci¯ded

=un¯=con_=tes=ted (adjective) 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 (adjective) 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 (*the bridge)* =i¯ye=fi_ra vs. =o_ye=fi¯ra or _to¯=ye¯=fi=ra

ο σκορπιός (*the 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 cymatically correct low final syllable pitch for nouns.

8.9 Identifying stress in languages with free stress

In languages with free stress a comparison of possible pitch alternatives finds the correct stress placement. 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.

коло́да (“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 existing 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.

=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*)

The other explanation for vowel harmony is physiological involving the divisions of the tongue. See (Tong, Gary Schweitzer’s manuscript 2108).
https://www.garystong.com/Vowel Harmony 2018/VowelHarmony 2018.pdf

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 (*star* nominative singular.), =stel_=lae (genitive sg.)

=mu=¯li_er, (*woman* nom. sg.) =mu_li¯er_=ris (genitive sg.)

Rhotacized nouns:

=mu_nus (*gift* nominative sg.), =mu=ne_=ris (genitive sg.) vs. =mu=ne¯=sis; (=mu_nus is classed as an r-stem noun, which should give “munur” but this would produce two adjacent highs: ¯=mu¯nur)

=stel_la (*star*), =stel¯la_=rum (genitive pl.)   vs. ¯stel_la¯=sum

=men_sa (*table*), =men¯sa_=rum vs. =men_sa¯=sum

=ge_nus (*kind*), =ge¯ne_=ris vs. =ge_ne¯=sis

=ve_nus (*beauty*), =ve¯ne_=ris vs. ¯ve_ne¯=sis

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 long. The examples below include singular nouns in the nominative case and verbs of the first person singular in active voice, and the first person singular of active deponent verbs. 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. tess**ē**_¯ra

tribus (*tribe*) **tri**_bus vs. **trī**¯bus

mālum (*apple*) **mā**_lum vs. **ma**¯lum

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 the appropriate high for 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 (*I ascend*), becomes =de=sc**e**n¯do vs. =de_sc**a**n_do
=tan¯go (*I touch*), becomes =con_t**i**n¯go vs. = con¯t**a**n_go
=clau¯do (*I close*), becomes =dis_cl**u**¯do vs. =dis_=cl**au**_do
=ca=pi¯o (*I take*), becomes =in=c**i**_pi¯o vs. =in_c**a**_pi=o
=sa_pi¯o (*I know*), becomes Eng. =in¯s**i**=pi_ent vs. =in_s**a**_pi=ent

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, cf. (Mountford [ed]. 1938). 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 -e and -i to the verbal root its pronunciation is obstructed, whereas the vowels added to the stem enable fluid articulation.

LEXICOLOGICAL INSTANCES OF CYMATICS

9.1 Filler words

Filler words and phrases in English like *man*, *you know*, *totally*, *if you will,* or *like* are intuitive tools for inserting low pitched syllables in a phrase in order to permit unobstructed cymatic undulation. 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=like_co¯ming =o_=ver vs. ¯I'm¯co_=ming¯=o¯=ver

=I'm_like_=thir=sty vs. =I'm_thir¯=sty

Certain word combination are adopted without a good cause other than to provide the correct cymatic pitch for final syllables, e.g., using *virgin olive oil* when *olive oil* would be sufficient except for its ending with wrong noun cadence pitch: virgin olive _oil vs. olive ¯=oil, or *a staunch ally* rather than *an ally:* =a _=staunch=a_lly vs. =an_=a¯=lly.

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 also appears to reduce the level of psychological concern for paying the price. Alternate configurations such as =ten¯=do¯=llars or =ten _=nine¯ty¯=five, etc., cannot compete with =ten_=nine¯ty_nine. The cognitional effect of final 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
=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 vs. _=bustle=and¯=hustle
=A¯dam=and_Eve vs. _=Eve=and¯=Adam

¯pea=ches=and_cream vs. _=creme=and=pea¯=ches

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
Musco_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
Tehran_i vs. Tehra_=ner or Tehrani_=an

b) American and British speakers, due to differences in their bases of articulation employ different words for same object, where possible alternates are acymatic:

American pronunciation	**British 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_=ment	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. Section 4.16). In physiological terms pitch in **intonation** is a processcreated 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) one of the three longitudinal layers, or in b) one of 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 techniques presented.

The cymatic functions of DSP were demonstrated in examples of **grammatical** formations (prefixes, definite 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 included 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. DSA also provides a tool reconstructing the phonetics of dead languages.

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 possibly precedes 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. The explanaton is provided in the **Appendix**.

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

The explanation to the question is that through combining into one structure the three pitch levels and nine lingual regions (indicated in Section 4.6 Figure 2) a 3x3 matrix of cells arises. In any of the nine cells a prime mover can be placed to define any of a large number of **unique** grammatical and lexical indicators. The nine lingual cells are synthesized through the intermixture of the three longitudinal and three axial divisions of the tongue as described in the Appendix.
The order of placing the prime mover and its antagonist in the 3x3 matrix 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 a particular cell. This is the **primary** configuration onto which **secondary**, modifying characteristics can be laid over, located in a different cell. 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.

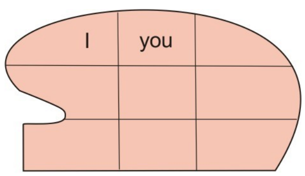
10.5 Simplicity in nature

Systems working with higher numbers of pitch, cf. (Pike 1945), (Pierrehumbert 1980), (Mertens 2001, 2013, 2014) and others, unlike (Campinoe and Veronis 2001) and the present paper using only three pitches, would not likely engage the interesting question mentioned at 10.3, the details of which are covered at 10.4 and in the Appendix. Notably that a mere three pitches with secondary superimposed gradations suffice to systematically indicate more than three lexical variables, grammatical factors and cognitive values. The general tendency of nature and evolution to prefer minimal components may account for this. Several functions in oral organization alone 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 three horizontal intrinsic lingual muscles (superior longitudinal, tranverse-vertical, inferior longitudinal), three axial lingual regions (tip, blade, body), etc. It is a fact that the most stable basic structural unit is the truss, consisting of three elements and that basic somatic movement, the peristaltic, operates with three interactive units (Seok et al. 2010).

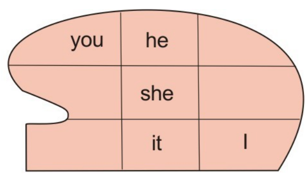
APPENDIX --- Cymatic marking of part of speech

1. There is a secondary level of discrete syllabic pitch (DSP) distribution below the cymatic level so far described. When verbs and nouns were characterized, respectively, by high and low final DSPs the discussion 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 parts of speech divide into grammatical categories, i.e., persons or tenses for verbs, number and possessive for nouns, and comparative degrees for adjectives, etc. The DSPs for these subclasses exist below the primary level as a secondary or *infracymatic* one. In Section 4.6 the divisions of the tongue were described as consisting of three horizontal and three axial regions. In practice these operate combined and are mapped out in the form of a 3x3 cellular matrix otherwise known as the *vowel quadrilateral*. Importantly, this matrix plays an organic role in several other lingual functions, as in DSP labeling discussed in Section 4.6 and as here, in distinguishing pitch assignments at the secondary DSP level, where, just as cardinal vowels appear in the 3x3 matrix, DSPs of grammatical subdivisions fall into various appropriate matricial cells.

In dealing with parts of speech in Section 6.11 **cognition** was already introduced into the discussion since cognition is a fundamental component of language. This can be further developed. At the neutral primary cymatic level, as a word without grammatical specification, the DSP of the first person singular pronoun *I* carries a high front DSP and the second singular person *you* has high mid pitch. But when taken as cognized entities these are mapped quite differently in the 3x3 matrix.
Cognizing *I* as the idea of self places 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 axial section. Note that this quadrilatreral matrix is not that of cardinal vowels *per se*, but one applied to the articulation of these pronouns.



neutral cymatic level



cognitive cymatic level

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 articulative frame overlaid on and obscuring the underlying 3x3 matrix. The following sections offer a more complete explanation of the secondary level DSP assignments of parts of speech. Successful empirical verification of the DSP diagrams below can come from looking at the images while generating the words.

1.1a The lingual mechanics underlying secondary grammatical DSP assignments is explained as follows. The prime mover of DSPs was described as the action in either the three **longitudinal** muscular layers, or alternately in the three **axial** sections of the tongue (Section 4.6). 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 or prime mover, the other one is the secondary agent, or antagonist.

1.1b In **agonist-antagonist** action the two agents can interact and alternately take the role of prime mover. Such behavior exists in vertebrate limb locomotion, in segmental undulation in movement in fish, reptiles, earthworms and caterpillars and others, in intestinal peristaltic movement (Tanaka et al. 2011), in alternate potentials in cardiac action (Nolasco and Dahlen 1968), and so on. It also occurs in terrestrial respiration as inspiration vs. expiration, in consonant-vowel sequences, or in the high and low pitches of cymatic waves.

This function also manages DSP **grammatical** assignments. Specifically, role alternations take place between the agonist and the antagonist agencies of **longitudinal** layers vs. **axial** sections in the grammatical pitch assignments (**GPA**s) of final syllables. Such scheme is illustrated in the diagrams below. In these diagrams the placements of bullets in longitudinal layers or axial sections are determined 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

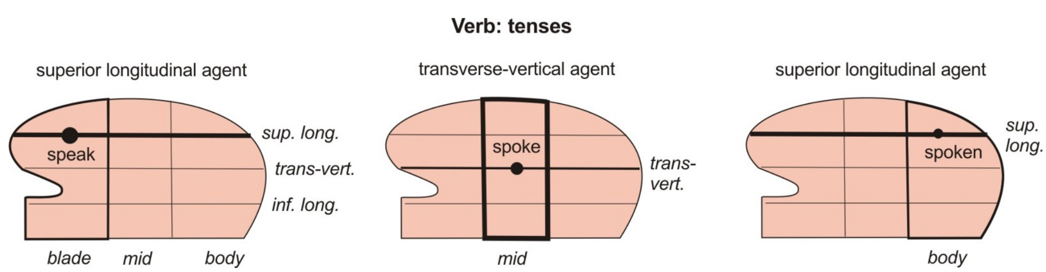
Secondary rank: verb past, noun plural, adjective comparative

Tertiary rank: verb past participle, noun possessive, adjective superlative

(The adverb and conjunction has only one rank)

Note: bold longitudinal line or bold outlined section indicates prime mover agency. The highest ranked function is shown with largest bullet; bullets decrease in size with decreasing grammatical rank.

1.2 Verb



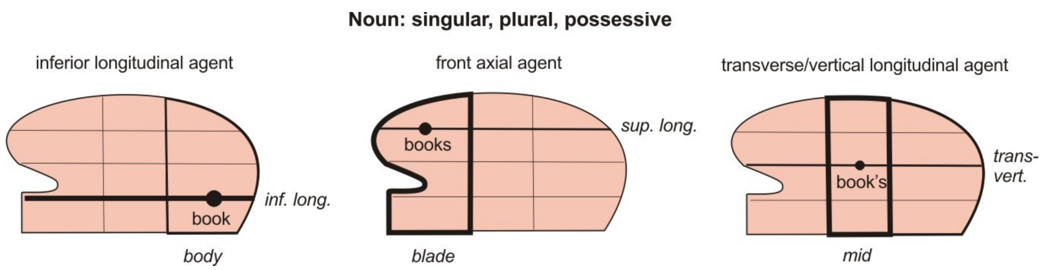
a. The innate general or base form GPA of the verb (without person and in the present tense) is represented by a bullet on the superior longitudinal layer, which is the primary agent, while the secondary agent, being the front axial section, is the antagonist.

b. For the past/preterite tense the GPA frame is secondarily superimposed on the base verb frame. The prime mover is now the axial mid section and the antagonist has moved to the transverse-vertical line.

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

d. The GPA frame of an unmodified non-conjugated verb or of a non-declined noun or of a positive adjective is the base frame on which the subframes of subsequent further grammatical modifications are superimposed in order of hierarchical rank. The base form remains embedded in such nested superimpositions. When a superimposed frame is lifted, the previous one(s) appear. The hierarchical 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

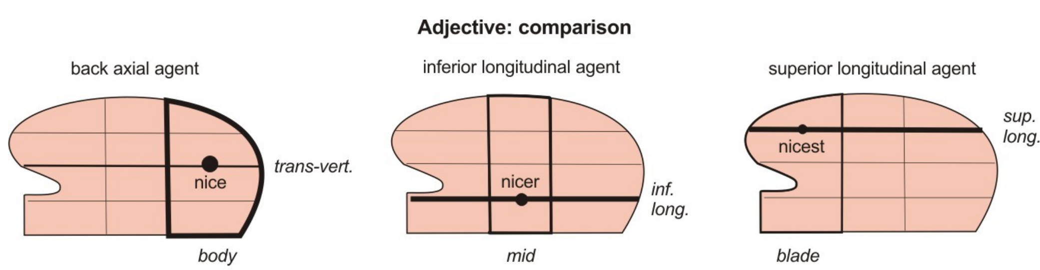


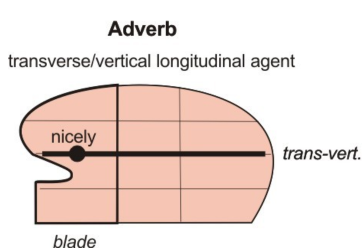
a. The primary agent of the singular noun GPA is at the inferior longitudinal level and the axial back section is the antagonist.

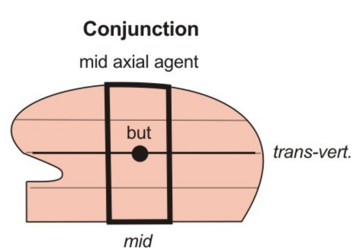
b. The plural noun prime mover of the GPA moves to front axial section while the antagonist is in the superior longitudinal.

c. For the possessive noun the GPA takes mid axial section prime agency and the antagonist is located on the transverse-vertical line.

1.4 Adjective, adverb, conjunction







a. The prime mover of the positive adjectival GPA is the back axial section, and the antagonist is on the transverse-vertical line. The comparative adjectival agent is inferior longitudinal and the antagonist is mid axial section. The superlative prime mover is superior longitudinal and the antagonist is front axial.
b. The GPA prime mover of adverbs is on the transverse-vertical longitudinal with a front axial section antagonist.
c. The primary agency of conjunctions is mid axial and has a transverse-vertical antagonist.

1.5 The ability of only three pitches, high, mid and low, to assign **unique** labels for eleven distinct grammatical entities is evidenced by the fact that there are no identical duplicates in the above diagrams. 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 *speak* and *books* both appear in the front axial section and on the superior longitudinal line, but one is of primary (present tense) verb rank, while the other is a noun of secondary (plural) rank. Similarly *speak* and *nicest* also share the front axial section, but contrast as parts of speech and in hierarchical rank.

part of speech	**primary agent /primer mover**		**secondary agent/antagonist**	
	horizontal level	***axial section***	***horizontal level***	***axial section***
verb present	superior longitudinal			front section
verb past		mid section	transverse-vertical	
verb past participle	superior longitudinal			back section
noun singular	inferior longitudinal			back section
noun plural		front section	superior longitud.	
noun possessive		mid section	transverse-vertical	
adjective positive	back section		transverse-vertical	
adjective comparative	inferior longitudinal			mid section
adjective superlative	superior longitudinal			front section
adverb	transverse-vertical			front section
conjunction	mid section			transverse-vertical

Table 2. Pitch assignments of classes of parts of speech

<u>REFERENCES</u>

Ayres, Thomas J. 1984. Silent Reading Time for Tongue-Twister Paragraphs. *The American Journal of Psychology* 97(4). 605-609. University of Illinois Press. doi: 10.2307/1422166.

Beckman, Mary E. & Gayle Ayers Elam. 1994. Guidelines for ToBI labelling. 2.0. Electronic document /opt/tobi/TOBI-TRAINING/labelling_guide-V2.ASCII on OUPLSun. https://www.ling.ohio-state.edu/research/phonetics/E_ToBI/.

Bolinger, Dwight L. 1958. A theory of pitch accent in English. *WORD* 14(2-3). 109-149. https://www.tandfonline.com/doi/pdf/10.1080/00437956.1958.11659660.

Brown, Steven, Angela R. Laird, Peter Q. Pfordresher, Sarah M. Thelen, Peter Turkeltaub & Mario Liotti. 2009. The somatotopy of speech: Phonation and articulation in the human motor cortex. *Brain Cogn* 70(1). 31-41.
doi: 10.1016/j.bandc.2008.12.006.

Campione, Estelle & Jean Veronis. Semi-automatic tagging of intonation in French spoken corpora. 2001. *Equipe DELIC Proceedings Corpus Linguistics*. (90-99).
https://scholar.google.com/scholar?hl=en&as_sdt=0%2C11&q=Campione%2C+Estelle+%26+Jean+Veronis.+Semi-automatic+tagging+of+intonation+in+French+spoken+corpora.&btnG=

Corley, Martin, Paul H. Brocklehurst & Susannah H. Moat. 2001. Error biases in inner and overt speech: Evidence from tongue twisters. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 37(1). 162–175.
https://doi.org/10.1037/a0021321.

Coleman, Jerald, Esther Grabe & Bettina Braun. 2002. Larynx movements and intonation in whispered speech.
http://www.phon.ox.ac.uk/jcoleman/project_larynx_summary.pdf.
https://www.researchgate.net/publication/246653491.

Coleman, Jerald. In *An Autosegmental Approach to Intonation.*
http://www.phon.ox.ac.uk/jcoleman/autosegmental_intonation.htm.

Crum, Robert J. & Raymond J. Loiselle. 1972. Oral perception and proprioception: A review of the literature and its significance to prosthodontics. *The Journal of Prosthetic Dentistry* 28(2). 215-230. https://doi.org/10.1016/0022-3913(72)90141-2. https://www.sciencedirect.com/science/article/abs/pii/0022391372901412.

Faulkner, William. 1930. A Rose for Emily. New York: *The Forum.* April 1930, p.1. https://americanliterature.com/author/william-faulkner/short-story/a-rose-for-emily

Fischer-Jørgensen, Eli. 1949. Kenneth L. Pike's analysis of American English intonation. *Lingua* 2 (3-13). https://doi.org/10.1016/0024-3841(49)90002-9. https://www.sciencedirect.com/science/article/pii/0024384149900029?via%3Dihub.

Fromkin, Victoria A. (ed.). 1980. *Errors in linguistic performance: Slips of the tongue, ear, pen, and hand.* San Francisco: Academic Press. ISBN 0-12-268980-1.

Gibbs C. H. & Messerman, T. 1972. Jaw motion during speech. *American Speech Hearing* 7(104–112).

Godinho, Sandra, Margarida V. Garrido, Michael Zurn & Sasha Topolinski. 2018. Oral kinematics: examining the role of edibility and valence in the in-out effect. *Cognition and Emotion* 33(5). 1-5. doi: 10.1080/02699931.2018.1532874.

Grice, Martine & Stefan Baumann. 2007. An Introduction to Intonation – Functions and Models. In Jürgen Trouvain and Ulrike Gut (eds.). *Non-Native Prosody, Phonetic Description and Teaching Practice (Trends in Linguistics. Studies and Monographs [TiLSM])* 186. 25-51. https://doi.org/10.1515/9783110198751.1.25

Gregory, Richard L. G. 1987. *The Mind.* Oxford University Press. p. 713.

Gussenhoven, Carlos. 2016. Analysis of Intonation: the Case of MAE_ToBI. Laboratory Phonology: *Journal of the Association for Laboratory Phonology* 7(1). 1–35.

doi: http://dx.doi.org/10.5334/labphon.30

Halliday, Michael Alexander Kirkwood. 1967. Intonation and grammar in British English. *Janua Linguarum. Series Practica* (48). https://doi.org/10.1515/9783111357447.

Hiiemae, Karen M. & Jeffrey B. Palmer. 2003. Tongue movements in feeding and speech. *Critical Reviews in Oral Biology & Medicine* 14(6). 413-429.
doi: 10.1177/154411130301400604.

Hillier, Susan, Maarten Immink & Dominic Thewlis. 2015. Assessing Proprioception: A Systematic Review of Possibilities. *Neurorehabilitation & Neural Repair* 23. 933-949.
https://journals.sagepub.com/doi/full/10.1177/1545968315573055.
https://doi.org/10.1177/1545968315573055.

Hirst, Daniel & Albert Di Cristo (eds.). January 2000. In Intonation systems: A survey of twenty languages. *Language* 76(92). 460-463. doi:10.1353/lan.2000.0088.

Ladd, Robert D. 1996. *Intonational phonology.* Cambridge Studies in Linguistics 79. Cambridge University Press. xv+334. ISBN 978-0-521-86117-5.

Li, Kun, Shaoguang Mao, Xu Li, Zhiyong Wu, Helen Meng. 2018. Automatic lexical stress and pitch accent detection for L2 English speech using multi-distribution deep neural networks. *Speech Communication* (96) 28-36.
https://www.sciencedirect.com/science/article/abs/pii/S0167639315300637.

Mertens, Piet. 2004. The prosogram: semi-automatic transcription of prosody
based on a tonal perception model. *Speech Prosody* 23-26. Nara, Japan.
https://www.academia.edu/17188755/.

Mertens, Piet. 2013. Automatic labelling of pitch levels and pitch movements in speech corpora. *Conference: Tools and Resources for the Analysis of Speech Prosody, (TRASP).*
https://www.researchgate.net/publication/280057279_Automatic_labelling_of_pitch_levels_and_pitch_movements_in_speech_corpora.

Mertens, Piet. 2014. Polytonia: a system for the automatic transcription of tonal aspects in speech corpora. *Journal of Speech Sciences* 4(2). 17-57. https://doi.org/10.20396/joss.v4i2.15053.

Mountford, James (ed). 1938. *Bradley's Arnold: Latin Prose Composition.* London, Longmans, Green and Co. Ltd.

Mr. Twister. 1st International Collection of Tongue Twisters. © 1996-2018 Mr. Twister. https://www.tongue-twister.net/.

Nolasco, J. B. & R. W. Dahlen. 1968. A graphic method for the study of alternation in cardiac action potentials. *Journal of applied physiology* 1968(2). 191-196.
doi: 10.1152/jappl.1968.25.2.191.

OpencourseWare 9 August 2006, 2.12 *Uncertainty in labelling*.
(https://ocw.mit.edu › courses › 6-911-transcribing-prosodic-structure-of-spoken-utterances)
This link out of date.

Orwell, George. 1949. *Nineteen Eighty-Four.* London: Secker & Warburg. ch. 1 (line 1).
http://george-orwell.org/1984/1.html

Pike, Kenneth Lee. 1945. *The intonation of American English.* University of Michigan Publications. In Linguistics (1). University of Michigan Press, (1945).
https://www.researchgate.net/publication/299580114_Pike_Kenneth_Lee.
doi:10.1002/9781405198431.wbeal0913.

Pierrehumbert, Janet B. 1980. *The Phonology and Phonetics of English Intonation.* MIT dissertation.
https://www.researchgate.net/publication/38004215_The_Phonology_and_Phonetics_of_English_Intonation.

Roberts, Philip J. 2012. Latin rhotacism: a case study in the life cycle of phonological processes. *Transactions of the Philological Society* 110(1).
https://doi.org/10.1111/j.1467-968X.2012.01285.x.

Rosenberg, Andrew & Julia Bell Hischberg. 2009. Detecting Pitch Accents at the Word, Syllable and Vowel Level.
Conference Paper, NAACL-Short '09 Proceedings of Human Language Technologies: The 2009 Annual Conference of the North American Chapter of the Association for Computational Linguistics, Companion Volume: Short Papers Pages 81-84.
https://academiccommons.columbia.edu/doi/10.7916/D8R78PK6.
https://doi.org/10.7916/D8R78PK6.

Science Friday. WNYC-FM, 93.9 FM. Dec. 6, 2013. New York.
https://www.sciencefriday.com/segments/speech-science-tongue-twisters-and-valley-girls/#segment-transcript.

Seok, Sangok, Cagdas D. Onal, Robert Wood, Daniela Rus & Sangbae Kim. 2010. Peristaltic locomotion with antagonistic actuators in soft robotics. *2010 IEEE International Conference on Robotics and Automation.* 1228-1233. doi: 10.1109/ROBOT.2010.5509542.

Serrurier, Antoine, Pierre Badin, Anna Barny, Lois-Jean Boë & Christophe Savariaux. 2012. The tongue in speech and feeding: Comparative articulatory modelling. *Journal of Phonetics* 40(6) November 2012. 745-763.
https://doi.org/10.1016/j.wocn.2012.08.001.

Tamburini, Fabio & Carlo Caini. 2004. Automatic annotation of speech corpora for prosodic prominence.
ResearchGate July 2004.
https://www.researchgate.net/publication.

Tanaka, Yoshimi, Kentaro Ito, Toshiyuki Nakagaki & Ryo Kobayashi. 2011. Mechanics of peristaltic locomotion and role of anchoring. *The Royal Society Interface* 10.
https://doi.org/10.1098/rsif.2011.0339.

Tong, Gary Schweitzer. The physiology of vowel harmony in Hungarian–Level 1. manuscript 2108.
https://www.garystong.com/Vowel Harmony 2018/VowelHarmony 2018.pdf.

Topolinski, Sascha, Ira Theresa Maschmann, Diane Pechner & Piotr Winkielman. 2014. Oral approach–avoidance: Affective consequences of muscular articulation dynamics. *Journal of Personality and Social Psychology* 106(60). 885–896.
https://doi.org/10.1037/a0036477.

Topolinski, Sascha et al. Onomatokinesia: The articulation movement makes the name. (manuscript submitted for publication 2014).

Weisser, Martin, *'25. Functions of Intonation'* (course work)
https://martinweisser.org/courses/phonetics/supra/intonation.html

Wolfe, Gene. 2021. *Shadow and Claw*. New York: Tom Doherty Associates. p.120.