THE ESSENTIALS OF SPEECH MECHANICS

SUMMARY

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CONTENTS

A. METHOD for analyzing the speech mechanism

1. Start with the root behavior of vocalization: **respiration**. Observe what functional modification of the respiratory framework generates the speech framework. Going from the simple to the complex, continue to reconstruct step-by-step the series of gradual modifications that lead to the structuring of speech.

2. Eliminate all **higher** level functions and **variables** of speech that are not fundamentals common to all languages. This is possible through authentic reproduction by a single person (who is both subject and observer) of the articulation of all major (or any) language(s), and judging which behaviors are characteristics of specific languages, and which belong to speech in general.

3. Observe and analyze speech behavior in precise **anatomic** terms. It is essential to clearly perceive the behavior of individual muscles and muscle groups in speech.

4. Evaluate data and and apply **rigorous** testing.

B. THE ESSENTIALS OF SPEECH MECHANICS

This outline describes the essential structure of speech, built as a hierarchical matrix of forces and their intersecting nodes/anchors the behaviors of which are governed by **glottoregulation** and **metaperistalsis**. These processes are described in the following pages.

ARTICULATION

A. Anchor farmeworks

a.1 Sling attached structures — "Floaters"

The interconnected organs of articulation, the tongue, velum, pharyngeal con trictors and hyo-larynx are relatively free "floating", structural units. They are sling-attached and are **moveable** in various directions by externally imposed muscles. These muscles come into direct contact and coactivity with each other without any intermediary bone, (excepting the hyoid bone which also floats). *See figs.a.1 and a.1.a.*

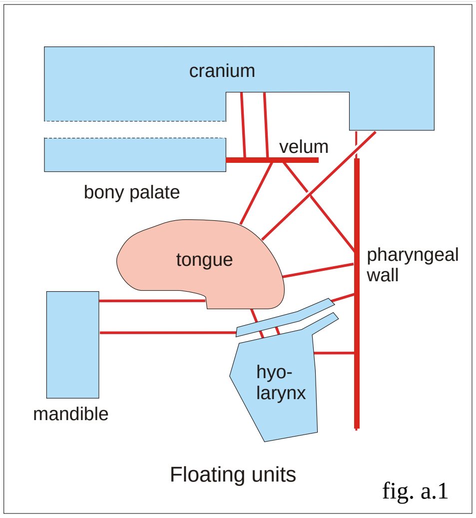


fig. a.1

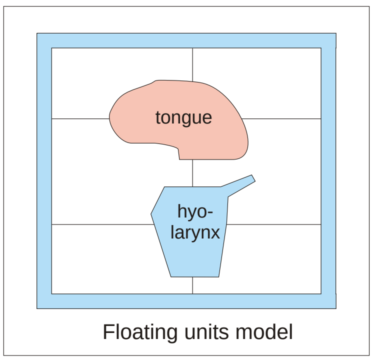


fig. a.1a

a .2. Nodes/anchors

Active **external muscles** inserting in such floating muscular organs spontaneously generate an **antagonist** stable **base** within the organ against which they can exert force. Within the organ, where the forces, or more generally their resultants, converge a region of tension develops and serves as a gathering point, or a **node** for these forces. *See fig a.2.*

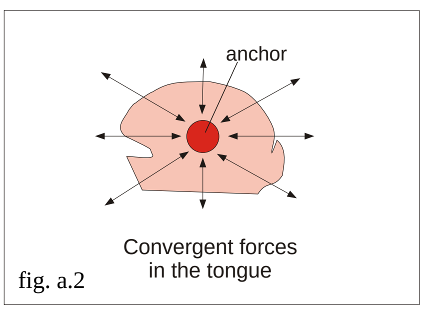


fig. a.2

In the sling attached structures such a node takes the place of bone, or cartilage, the normal **anchoring** material of muscles. The size and location of the anchors varies with the identity and energy level of the incoming forces. The anchor may be called an analog of the center of mass of a system. (*See Appendix: center of mass*)

The main agent of articulation is the tongue and the forces, or their resultants, of its extrinsic and intrinsic muscles converge at one specific region of the tongue mass. Such a region is a lingual **node** or lingual **anchor,** through which the incoming forces are unified to work as a single mechanical **framework.** The tongue performs several functions and has an appropriate anchor frame serving each.

a. 3. An anchor lies at the dynamic center of its framework of forces. (Cf. F.1. Envelopes, below.) Except at sufficiently low energy states of its muscular frame an anchor remains masked by superimposed frames. fig. a.3 (See g.8 *Superimposition*, and g.10 *Masking* .

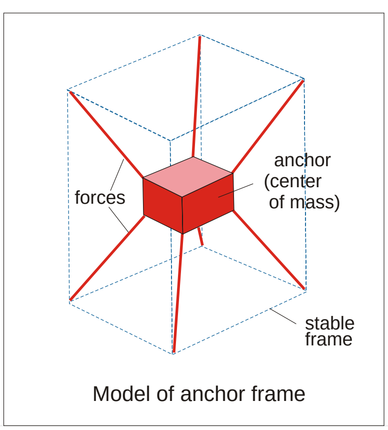


fig. a.3

a. 4. The speech framework

Nodal structures exist in each of the "floating" organs of speech and their monadic interaction forms a composite **matrix** or **unit framework** analogous to a geometry of linear forces interactively "hinged" at various nodes. See fig. a.4.

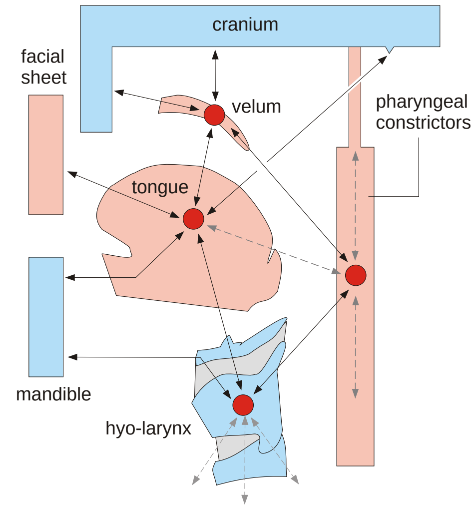
Reducing **complex** speech production to a unitary mechanical matricial device of nodes and convergent forces gives us an effective tool for analysis. It can be expected that, like any system, the "floating" speech organs, without a cohesive, integrated structuring would be highly inefficient in their actions and interactions.

The functional integrity of the separate subunits is generated by a physiological regulatory mechanism centered around the larynx, providing a **constant** against which the many variables in speech can operate, one which directs or regulates the pattern of their cooperative behavior. (This constant, **glottoregulation,** briefly described below, is discussed in section *Fundamentals of Speech*.)

Alternate articulation occurs whenever within the global monadic mechanism any of the various anchors or forces initiates coactive behavior by the others. The symmetries of this framework underlie the agonist-antagonist interactions of speech activity.

Due to such **monadic** unity any subframe of sound production will uniquely reflect the behavior of the entire larger frame structure. The map of forces in the framing of a specific language will differ significantly from those of others in measurable ways. Variation in gesticulation is evidently characteristic of different languages, but we can readily shown that this is not cultural but physio-mechanically formed behavior. See figure a.5.

The framework mechanism allows us to systematically distinguish and analyze the components from the whole framework. The speech system has three major sub-components: a) articulation, b) phonation and c) speech respiration.



The lingual anchor matrix of speech

This simplified diagram shows the lingual anchor as the central agent of the speech framework and does not include the mandible, the oral sphincter, respiratory organs, etc., as these may be considered secondary articulators. Other outlying musculature includes the infralaryngeals. For simplicity the hyoid bone and the larynx are here condidered a single mechanical unit.

fig. a.4

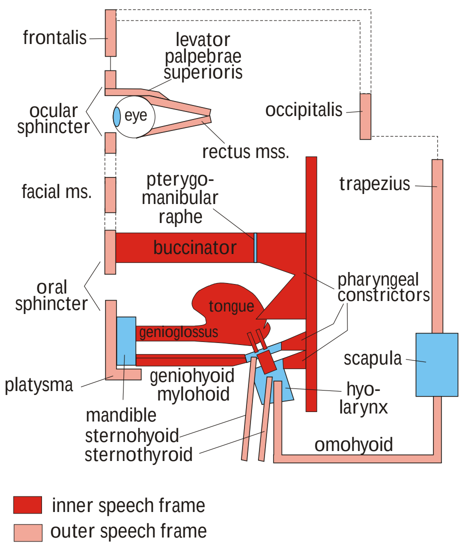
Note: The mechanics described here are easiest to follow and are immediately understood through first hand experience in proprioception. To do so it is essential to set the expertimetnal framework by reducing to a tonic level all direct and indirect parts of speech production, or simply put, to sufficiently relax these. At that time anchors located and isolated and their behaviors can be analyzed. Several of the many available methods for finding and perceiving lingual anchors are offered in the Appendix, p.000

B. Behaviors

b.1. Glottoregulation

Glottoregulation is an agonist-antagonist **balancing** of forces surrounding the **larynx** that maintains the appropriate optimal glottal state during all actions of the upper visceral system. Since the larynx is to a measurable degree highly sensitive to external pressure, and its distortion by **external** forces creates immediate glottal stricture, there is an **equalization** behavior built into the speech mechanism which constantly the glottal state by balancing compensation for external distortions. Every instance of speech production contains a glottoregulative factor. (This topic, including data demonstrating this process is covered in section *Foundations of Speech*).

fig. a.5 Surrounding framework



The **mandible** is directly tied to lingual anchors through the genioglossus muscle, etc. The **facial** musculature is connected to the pharyngeal constricters through the oral sphincter and buccinator. The (external) eye muscles, aside from neural paths, are united with the facial sheet through the levator palpebrae superioris.

Note: Accessibilty to measurements:

The lingual frame is the **central** agent of speech but its muscular behavior is difficult to instrumentally measure. However, **externally** to the lingual frame there lie, monadically united with it, coactive subframes including those of the lips, mandible, face, eyes, arms and hands that are observable and accessible to measurements. Any action of the tongue has a unique corresponding counterpart in the musculature of the face, hands, arms, eyes, etc. Cf. the built-in coaction of sound production and head movement in animals and especially gesticulation in humans. **(***Details in Chapter 000*).

Figure a.5 shows the main connections between the inner and outer frameworks of speech. The velar apparatus is not included for simplicity.

Since facial behavior, gesticulation, voice pitch, etc. distinctly varies among the major language families, languages, and to a lesser extent among individual speakers, data can be collected from such externally accessible regions to help reflect the behavior of more interior, inaccessible regions of the frame.

b.2. Metaperistalsis

The second basic mechanical function of speech is a highly developed form of peristalsis. The most **primitive** behavior of the pharyngo-visceral tract, which later evolved into the upper respiratory-masticatory, or upper visceral (UV) tract was **peristalsis.**

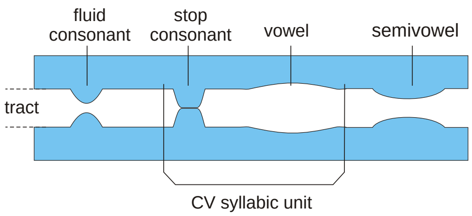
As evolution is a process that modifies, rather than creates ex nihilo, it may be inferred that the mechanics of the modern UV are complex developments of peristalsis. In fact, this appears justified because the interpretation of speech in such terms easily and consistently explains its behaviors. Syllabification is one instance. The diagrams of the wave of phonation of the word "tomato" as closed-open sequences and of the sound produced by a goat on slides by MacNeilage (source) are diagrams of peristaltic waves.

To differentiate the more complex articulatory and masticatory mechanics of open-close sequences from simple one-way passages of bolus, this behavior involved can be termed **metaperistalsis. (**For additional details, see the section *Phoneme Production*, p. 000, (not included in this outline). **Peristaltic** action has been **recognized** as the mechanical function of suction and of bolus transport in **suckling.** Cf. Woolridge, 1986; Buckley, et. al 2006, and others listed on p. 22.

The earliest vertebrate ancestral feeding tube was **linear**. Metaperistalsis evolved as a complex reorganization with bifurcations, detours and overlaps of the original linear tract when a) the nasal and the aural tracts emerged from the oral and pharyngeal line and were repositioned, b) when the jaw and tongue and allied musculature appeared, c) when the hypobranchial (under-gill) muscles moved to cover the face, head, neck and shoulders and were physically connected to the branchial (gill-derived) structures of the tract such as the hyolarynx. This has produced complex overlapping, simultaneously occuring patterns of peristaltic expansions and constrictions. For instance, while a vowel is expansive, its simultaneously occuring phonation further down the tract is constrictive.

fig. b.1

Peristaltic patterns in articulation



In this diagram dashed lines indicate the median cross-section of the tract. Vowel and consonantal expansions and compressions of tract segments are shown for various syllables types.

1. Any syllable, whether vocalic or consonantal (V, VC, CV) is built from peristaltic units, from a variety of patterns composed of partial phonating closure, full tract closure and open tract units. These actions are partial or complete peristaltic three-element movements.

2. The production of phonemes is also a modified peristaltic derivative. Full stops are complete closures, while other phonemes, vowels and consonants (voiced, voiceless, affricates, fluents, etc.) are modified epansions expansions and closures of the tubular tract.

In view of the discovery of the **genetic toolbox**, which supports the notion that nature builds on existing resources**,** it is not surprising that peristalsis can be shown to be the fundamental behavior later modified into a more complex system of respiratory, masticatory and sound producing mechanics that we can call **metaperistalsis**.

Peristalsis occurs when tubular visceral tract undergoes a segmentally moving wave sequence of alternating contraction and expansion of tract cross section. Such behavior has been recognized in suckling and deglutition, but metaperistaltic functions can be successfully interpreted to generate all actions of the upper respiratory-visceral tract and so underlie speech production as well.

The upper visceral tract contains muscles of somatic developmental origin as well, however these unite with the true visceral structure to generate behaviors that are mechanically still visceral.

The ordered sequences of **metaperistalsis** can be developed into more complex behaviors by **modifications** such as combining peristaltic segmental units or elements in variant groupings and in directional reversal. (Note that whereas primary power in respiration generates inspiration, in speech the primary power is assigned to expiration. Cf. also food input vs. Regurgitation).

An example of visceral segmental functioning in **speech** is in syllabification. *See fig. b.1*. Phrasing, on the other hand, reflects metaperistaltic segmentation in **respiration**.

As sound production is a coaction of articulation and respiration (the latter in the form of pulmonary pressure, phonation and speech respiration), speech mechanics can be seen as a combination of two different sources of peristaltic action. The **integration** of respiratory and masticatory behaviors in a complexly constructed alternation of contractions and expansions in particular sequences underlies the **functions** of the upper visceral system, the main ones being respiration, feeding (suckling/ mastication/deglutition) and speech. In respiration one breathful of air is a metaperistaltic segment. “Breathfuls” can be added by segments or glided into continously without obstruction. A **yawn** glides through all segments with maximal tract expansion. (For details see Chapter on Respiration, Chapter 000.)

b.2.1 Support for the *frame and content* theory of MacNeilage and Davis

Metaperistalsis clarifies both the **frame** and associated **content unity** and its **serial/parallel** forces components proposed by MacNeilage and Davis. Peristalsis has two force components: longitudinal and transverse. In the mechanism of sound production these manifest as the **serial** and **parallel** aspects of speech. The unit CV frame-plus-content is, on the other hand, interpretable as the module consisting of two consecutive peristaltic segments, in which the content is **parallel** or **transverse** and the sequence of C and V is **serial** or **longitudinal.** A description of the basis for the constancy and detemination of the frame content is not covered here as it involves additional combined functions involving the jaw, tongue and the cyclicities of food ingestion, in suckling (cf. Woolridge, 1986) and in mastication (cf. Hiiemae and Palmer, 2003). For details see Ontogeny of phonemes, Chapter 000.

C. Hierarchical organization

c. 1. Hierarchical series of anchors

Speech production, being an ordered system, is **hierarchically** organized. In terms of anchors this means that there is for a given function a single t**op level** node which controls, or interacts with a number of lower level nodes. This is a two-way relationship; a higher anchor is to an extent affected by subordinate anchors when these are present. (The source and mechanics of hierarchical sequence ordering is not discussed here.) See fig. c.1.

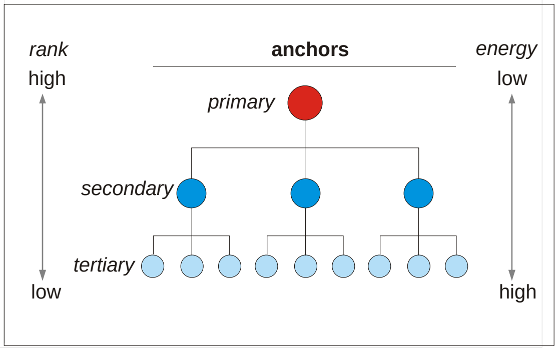
Hierarchical rank is a function of the amount of **energy** input applied to a particular framework. The mechanical behavior of the speech mechanism is such that it is "pre-wired" to initiate and complete action sequences when energy is applied. When going into the speech mode, as energy input increases, so does tension, cross section of oral tract, and the degree of approximation of articulative posture. (Cf. increase in size of oral tract cross sections in relation to energy level of respiration.)

The "pre-wired", **built-in** a nature of anchor sequences is the basis of language learning. Without such device the acquisition of human speech or for that matter, that of certain animal vocalization would be excessively complicated. Similar built-in automatization is evident in suckling, eating, walking, etc.

When the speech framework is present, with increasing general tension applied to the framework, starting at the lowest energy level, the framework passes through successive hierarchical levels. Normally this passage through levels can be rapid, and apparently simultaneous, but its is observable when tension is gradually increased, either experimentally or in moments of naturally slowed speech.

A natural hierarchical sequence is the dynamically optimal path of transition between anchor frames. It is therefore present in all efficient movements, e.g., as in the locomotor behavior of limbs. Hierarchical sequences, i.e., dynamic paths can be terminated and switched to other paths through glide or pulsed transformations. (See anchor transformations, g.11).

fig. c.1



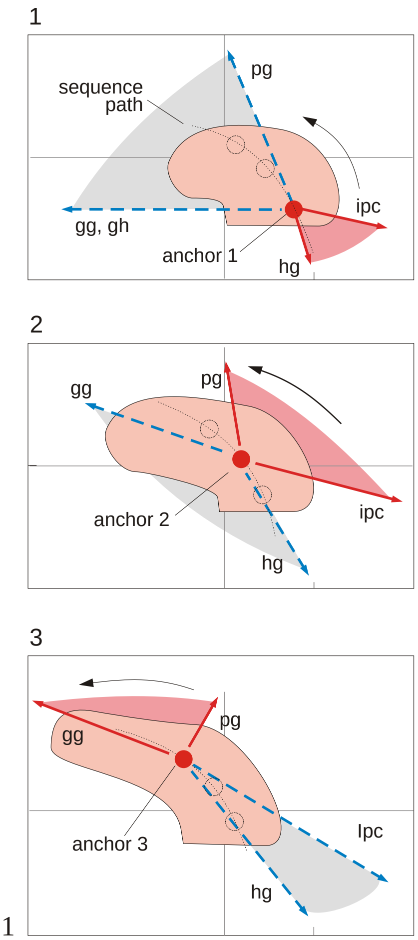
c.2. Models of hierarchical sequence

The simplified schematic model, fig. c.1, of a hierarchical sequence shows an optimal linearly consecutive superimposed series of anchors developing through increasing energy input. This route of tension expansion is defined as optimal because an anchoring travels using minimal energy—across the most efficient path.

Each anchor activates a specific framework of muscles, which naturally partly overlap those of other anchors, resulting in the temporary sharing of forces by different anchors. The anchor sequence functions may proceed in a fluid, pulsed of mixed manner. (See, anchor transformations, g.11.)

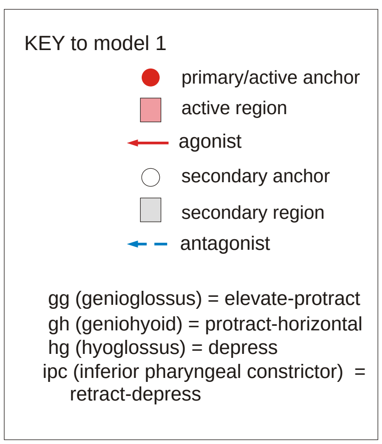
The simplified schematic model 2 in fig. c.2. using only four extrinsic forces to represent the entire framework, shows a particular lingual anchor sequence as agonist-antagonist roles gradually overlap and shift during changes in the mapping of forces. The **architecture** of the speech system here shows a **metaperistaltic** process.

Hierarchical sequence model 1

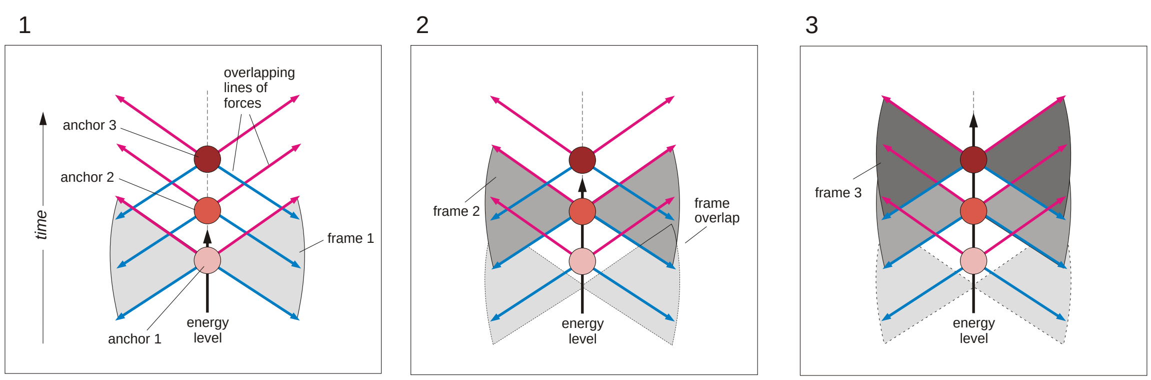


c.1

Movement of active region through movement of anchor sequence



Hierarchical sequence model 2



c.2

Movement of active anchor frame as force increases

d. The hierarchical organization of speech anchors

d.1. Speech is generated and organized through an architecture of **hierarchical** anchor ordering. The highest level node, or most general anchor of a given function, is created and maintained with the smallest amount of energy expenditure. Lower level nodes increase in number and require more energy to produce and maintain, therefore they will always tend to decay back to lower energy states.

Generating the speech frame starting at the lowest energy level is such that the series progresses by **alternating** between anchors in the two different tracts, or channels, one respiratory (expansive) and one masticatory (constrictive), as in fig. D.1. The reason for this lies in the essentially metaperistaltic and glottoregulative behavior of the tract. (See b.2 Metaperistalsis) See also fig. e.3.

When the speech frame is sequentially generated starting from anchors in the upper visceral (UV) tract structure, this tract functionally changes from respiratory/masticatory to a vocal/articulative phonatory tract sructure.

At each level the speech anchor hierarchy contains two lines of anchors (respectively, the respiration and mastication based vocalization and an articulation anchors), but since in actual speech these anchors merge (See g.9 Mergers), we can represent the hierarchical sequence as a single line of **merged** vocal and articulative anchors as shown in figure e.4.

One can directly enter the anchors of the hierarchical line at any level, that is, go to the full speech level **directly** from a lower level pre-speech frame, but such action is **unnatural** and the produced speech is inefficient. Normally one passes through the hierarchical series by gliding at variable speeds, rather than through stepwise gradients. At least one intervening level is easily perceptible: that of the preparatory setup immediately preceding speech production, or level 3.0, the anchor of the basis of articulation of the specific language. It is at this level that the respiratory mode changes into that of speech **respiration,** in which effort occurs on expiration, rather then in inspiration.

d.2. Definition of the term vocalization

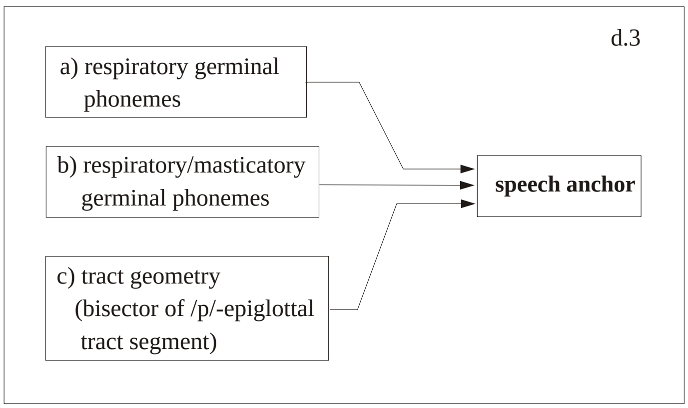
In this description the somewhat ambiguous term vocalization needs to be defined. Here ***vocalization*** refers not to producing a sound, but only to **tract shaping** behavior, excluding glottal phonation. Tract formation serves in both respiration and in vowel (plus certain consonantal compensating factors) of articulation. These two cannot be divorced: potential vowel shaping tract spaces are inherent in all states of respiration. In contrast to tract expansive behavior of vocalization, articulation is constrictive.

Note: Vowels contain articulatory configurations by the tongue and other parts with minimal tract occlusion. Breathing while holding a vowel tract is inefficient but possible. On the other hand, consonantal tracts, including semivowels, seriously restrict respiration. In fact, vowel shaping and phonation are respiratory functions. Even with phonation absent, all modulated states of respiration generate particular tract shapes characteristic of basic vowels and consonants : cf. yawning = /a/; laughing = /i/ or /a/; positive surprise = /u/; fright = /o/; normal nasal breathing = /ə/ (neutral vowel), /h/, /n/, /m/ (depending on body stance); normal oral breathing = /h/. It is easy to observe that at different levels of intensity in oral respiration, the oral cavity, with widely open mouth, takes on various basic vowel shapes. (For further discussion Chapter Phoneme Production, 000.)

d.3. The derivations of the speech anchor.

There are **several** paths for generating the speech anchor. The one outlined below is the one based on the lingual anchor of **respiration** (a). Other methods employ (b) anchor mergers of primitive (or germinal) phonemes inherent in **respiratory/masticatory** tract behavior and (c) **tract geometry** (see Appendix). See fig. d.3.

Method (b) is briefly described in d.4 before going to respiratory source covered on page 11; for more details on germinal phonemes refer to chapter *Phoneme Production*, p. 000.



d.5. Hierarchical ranks of speech anchor generation

Hierarchy of lingual speech anchors

1.0 General vocalization anchor
1.1 General articulative anchor

2.0 Phonetic language family vocal anchors
2.1 Phonetic lg. family articulative anchors

3.0 Specific language vocal anchors
3.1 Specific language articulative anchors

4.0 Specific language vowel anchors
4.1 Specific language consonant anchors
...

5.0 Anchors of coordinated articulation, etc.

fig. d.5.1

d.4. The derivation of the speech anchor from respiratory-masticatory germinal phonemes

The general **vocalic** anchor is the merger of the germinal phonemes /h/, /n/, /m/ and /ayin/; that of the **consonantal** one is the merger of the germinal /p/, /t/, /k/ and /q/ anchors. These two anchors fuse to become the anchor of ongoing speech, shifting in primacy through the rapidly alternations the vocalic or consonantal features of speech. It may be noted that the imperfections in the speech of the deaf is in part due to their generating the speech anchor from an incomplete set of germinals. The **germinal phonemes** /h/, /n/, /m/ and /ayin/ and /p/, /t/, /k/ and /q/ derive respectively from respiration and mastication.

For details on this topic see chapter *Phoneme Production.*

Figures d.5.1 and d.5.2 refer to *section E. The anchor series of speech generated in the respiratory frame*, p. 11.

Merged lingual speech anchors

1.0 General speech anchor

2.0 Phonetic language family anchors

3.0 Specific language basis of articulation

4.0 Specific language articulation anchors
...

5.0 Anchors of coordinated articulation, etc.

fig. d.5.2

d.6. The alternate derivations of the speech anchor and phoneme sources from the respiratory and masticatory frame.

Respiration is hierarchically higher ranked than the more energetic mastication process. Similarly, the sources of respiratorily derived the vocal anchors h, n, m, and ayin are of lower energy than the inherent base consonants derived from mastication, p, t, k and q. See *fig. d.6a.*

In the first derivation the inherent **germinal** phoneme elements of the **speech respiratory** frame, h, n, m, and ayin having taken on their vocalic anchoral aspects, merge to produce the common vowel anchor, from which all vowels are generated. The primary ones are /i/, /a/ and /u/, which are the inherent vowels of the upper visceral tract. These merge, in turn, to give the secondary vowels /e/ and /o/. Other variations of vowels such as open, close and rounded, etc. and the production of consonants involves additional merger functions of the germinal vowels. The masticatory consonants can also arise from the merger of the respiratory phonemes, but at an energy level higher than that for generating vowels, and at a modified mandibular setting, see *fig. d.6b*. The different settings of the mandible, which are integral agents of UV functions are directly connected with generating the anchors of speech and feeding etc., see Part 4. *The mechanics of speech ontogeny/*section 3.

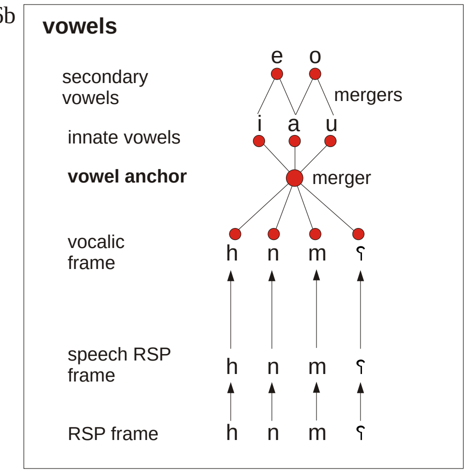
Starting in the **masticatory framework,** the inherent vocalic germinal phonemes, h, n, m, and ayin, which in food processing are tract shapers serving masticatory respiration, merge to form the common consonantal anchor. From this arise the simple stops, the velo-lacunar /j/ and /w/ and the lacunar /l/ and /r/. Speech during mastication is feasible only when the respiratory air direction during food processing changes momentarily to masticatory speech respiration, in which energy occurs in expiration, not inspiration. *See fig. d.6c.*

The flexibility of generating speech is enabled but the fact that anchors and phonemes can be produced from several sources in several ways.

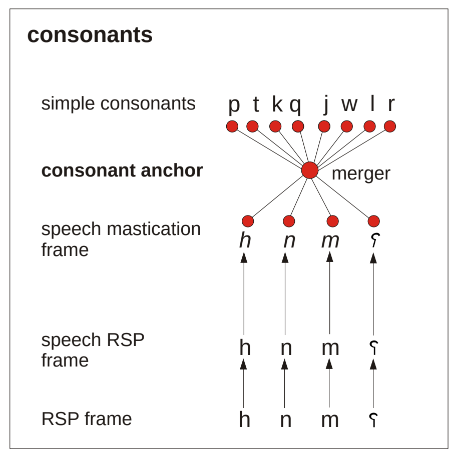
d.6a

higher level	mastication	d/n/g a/i/u	higher energy
lower level	respiration	h/n/m/ʔ	lower energy

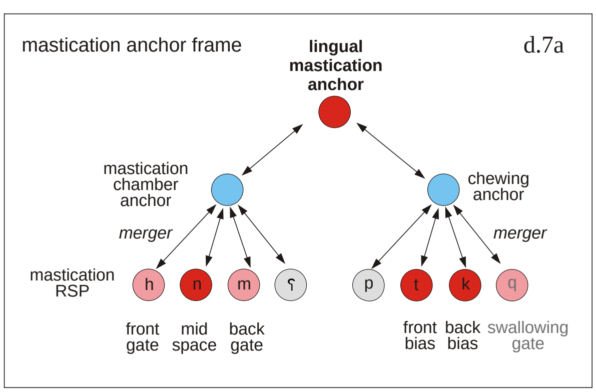
d.6b

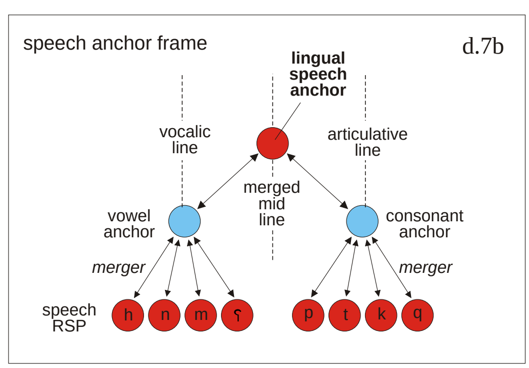


d.6c



d.7. Alternate hierarchical sequences of generating speech, respiration and mastication anchors





E. The anchor series of speech generated in the respiratory frame

0. The parent source anchor

Abbreviations:
⚓ = anchor, **G** = general, **Voc** = vocalization,
A = articulation, **s** = specific, **L** = language,
Phon = phonetic

0.0 The immediate parent/generative source of the hierarchical anchor system of speech is the **lingual anchor of nasal respiration (0.0)**, the node region of the tongue coactive with the remainder of the respiratory muscular framework. This anchor serves the neutral or resting state of respiration where respiration is **nasal**, with mouth closed.
See fig. e.1

0.1 The next level, if the route of the respiratory hierarchical sequence were continued, passing through stages of increasingly energetic respiration, and growing oral aperture and air-tract cross section, would be the **first oral respiratory** level, initiating the line of mouth respiration (**0.1)** *See fig. e.1*

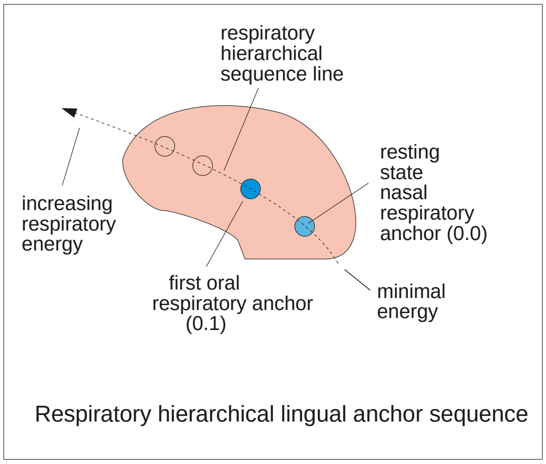


fig. e.1

1.0 General speech anchor

1.01 The highest level of speech production is the **general anchor of vocalization (1.)**, which is generated by a combination, or merger (see f.3. *Mergers*, below) of the **lingual rest state respiratory anchor (0.0)**, and the anchor of the f**irst oral respiratory level**, **(0.1)**. This merger switches, or redirects the course taken by the hierarchical sequential line away from the respiratory route to the vocalization route. Speech structuring, mainly the presetting of **phonation**, begins here, but the vocal quality is primitive. **(Gvoc).** *See fig. e.2*

1.02 The following level is that of **general articulation (GA)**, the nuclear source of general (primitive) phonemes, which is also the merger of the respiratory and masticatory anchors. Vocalization is here limited to phonemic sounds, excluding those of other vocal modes, such as crying or laughter. The actual vocal quality here is primitive. Articulation involves the innate consonantal qualities of mastication (S*ee Appendix: Phoneme Production, and the descriptions of Speech Ontogeny and of Mechanism of Mastication*).

1.03 If speech starts in oral respiration, then the series begins at the 0.1 **(** first oral respiratory) anchor.

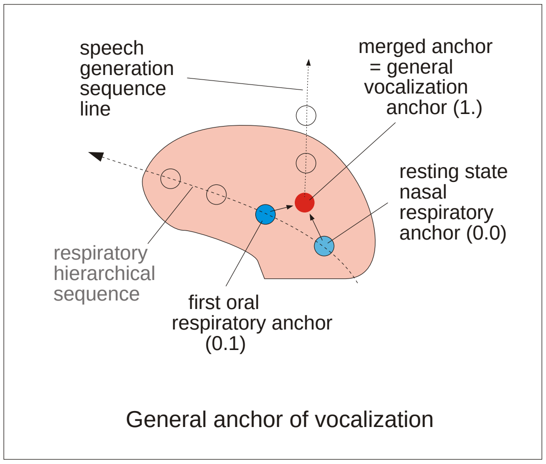


fig. e.2

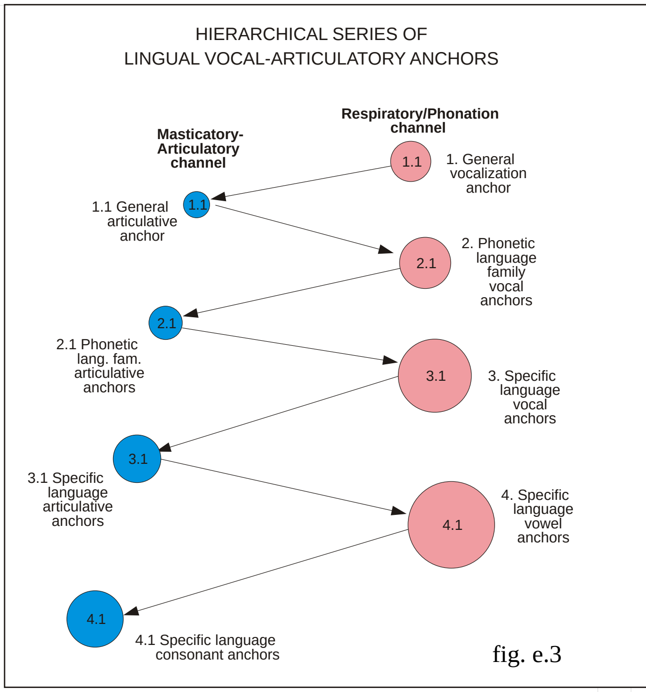


fig. e.3

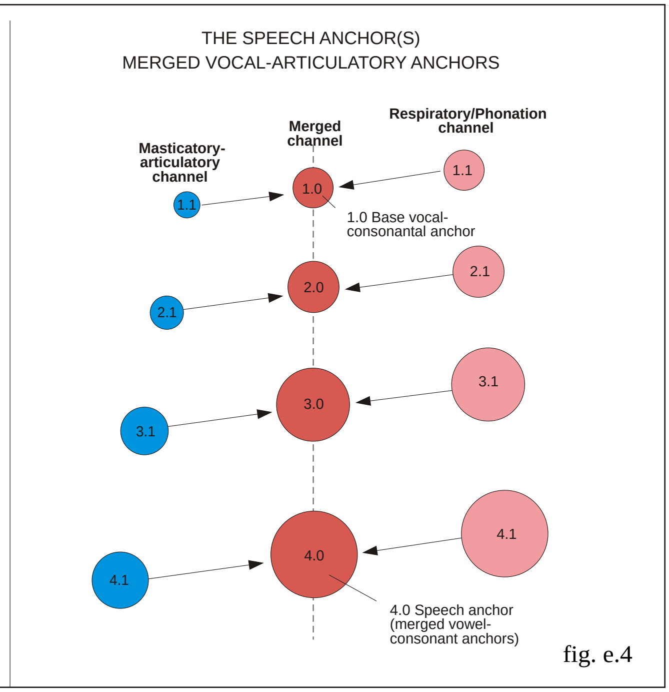


fig. e.4

1.1 The alternating hierarchical series of anchors

Fig.e.3. depicts the **hierarchical** order of the stages in the spontaneous generation of the speech anchor. The progress alternates between the channels of anchors of the masticatory line and those of the respiratory line. Apparently this hierachically ordered line of anchoral sequence is a peristaltic series of open (or vocalizing) and closed (or articulatory) alternating segmental actions.

The merged hierarchical series of anchors

Fig. e.4. illustrates a secondary routing of the anchor generation path, in which the path moves through a progression of merged anchors that are combinations of the corresponding anchors at each level. The path begins with anchor 1.0, the merged anchor of the basic vocalic and articulative functions, and it ends with anchor 4.0.

Ongoing alternation in speech:

During active speech, while the anchor 4.0 remains as the high-ranking enfolded anchor of the framework, the active section of the framework alternates between vocalic and consonantal anchors, producing syllabification. Such behavior is part of maintaining, by sequential equalization, the median cross-section of the upper visceral tract.

2.0 Phonetic class anchors (PhonClass ⚓)

2.1 Next in line are the general **vocalizing** anchors of phonetically related languages (or **pronunciation-class** families e.g., Slavic languages), which serve to preset a type of oral space and its potential vocalizations from which the next level (2.2) can abstract further delimited and refined phonological frames. **(PhonClVoc⚓)**

2.2 The anchors of the general articulations of phonetic classes.) A quickly passing, respiratorily inefficent and constrictive level. **(PhonClA⚓)**

3.0 Specific language anchors (spL⚓)

Following are the levels of the anchors of

3.1 Specific lang uage general vocalization (SLGVoc⚓) and

3.1 Specific language general articulation (SLGA⚓).

It is at these levels that competent speech is produced. (Children learning to speak reach this level only after passing through previous ones.) The product of the merger of these two anchors is the so-called **basis of articulation** of that language, and is the source of the specific vocalic and consonantal anchors and of all other unique qualities of a given language. Vowels and consonants can be produced at the higher anchors as well, but are inefficient and primitive, (animal) vocalizations.)

4.0 Specific phoneme anchors (sPhon)

4.1 Below this is the level of **specific vowel anchors (sVA)** particular to a given language. Each vowel is produced by its own anchor.

4.2 The next level is that of **specific consonantal anchors (sCA)** which tend to be always superimposed over a vowel anchor. Consonants are modifications superimposed upon vowel frames and each vowel anchor generates its own particular set of consonants, although the consonant, in turn, influences the vowel. (Cf. below, *Mergers*.) Each consonant is produced by its own (sub)anchor/or secondary anchor.

Note a: Passing up through the level ranks the energy of articulative action constantly increases. This process is monadically tied to simultaneous energy increases applied to the energy of the forces active in both the articulatory and phonatory apparatus, generating the appropriate glotto-laryngeal configuration and behavior to a given anchoral rank level.

Note b: Levels 3.1 and 3.2 differ from previous ones in being more **stable,** enabling maintenance of continuous speech frame without undue effort, whereas the anchoral ranks situtated between the resting nasal respiratory anchor (0.0) and the anchor of general language anchors of a specific language (2.1 and 2.2) are not stable and tend decay to the lower levels. Importantly, at this level the normal respiratory mode has fully switched to the mode of **speech respiration**, which is relatively stable and maintainable in the speech preparatory stage, *(details in chapter Respir. 000.)*

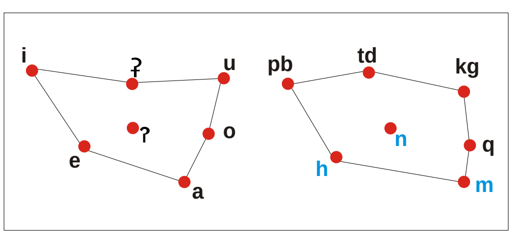


fig. e.5
The consonant and vowel quadrilaterals

Note c: the specific Lg anchor system

The so-called vowel quadrilateral is a basic matrix structure used to classify vowels but it can also classify consonants. See *fig. e.5* and also section *g.2 Vowel envelopes.*

Moreover, the **spL anchors** (3.0) of each phonetic language family and its member languages are positioned in such quadrilateral matrix. At this level actual speech phonemes are not produced, only the anchor and anchor path network of a particular language family or member is set up. The phoneme approximately associated with the matrix box in terms of vowels (or consonants) is embedded within the phonology of a language and influences that phonology. Typically the phoneme most closely identifiable with a spLg anchor is one that is not efficiently pronounceable by that particular language. French, with its spL (3.0) anchor approximating a type of /h/, for example, lacks that phoneme because the musculature already tied to the anchor is limited in reaching a palatal target. Languages where /w/ is problematic, similarly would have a spL anchor related to /w/.

Thus, we can classify spLg anchors as providing, for instance, a central-high or a back-mid articulative basis. Good examples are provided by Chinese and English. Although totally unrelated in any way, both are articulatively based in the /i/ bracket, although at different positional heights, and so share such qualities as a being or tending to be monosyllabic (regarding the original Old English based vocabulary), pentatonic musical scaling and using a multitude of phonological segments common to both languages. (In English spelling these include: go, shoe, chin, chow, cow, chew, coo, two, toe, so, do, tin, din, bin, pin, sing, song, tongue, long, fay, fun, toe, rue, chop, guy, lee, low, mow, gin, yeo, my, sigh, high, lie, eye, come, hoe, pie, pay, bay and many more.) The syntactical grammar of both is also related to such spLg anchor positioning.

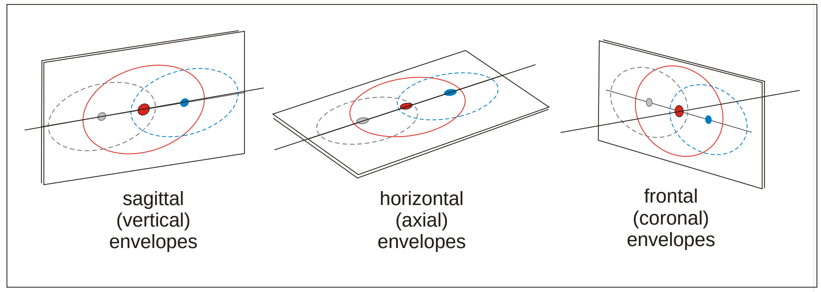
Consonants can be located in a quadrilateral field as readily as vowels are by first producing a soundless /p/ (i.e., with no air pressure) and then moving to /t/, /k/, etc. Voiceless and voiced consonants form separate fields. /h/, /n/ and /m/ belong to both, while /q/ has no usable voiced speech version.

F. Trimerism in the anchor system

f.1. The speech framework has vertical (sagittal) and horizontal (axial), frontal (coronal) aspects and a tripartite envelope system resides in each. An articulative tract shaping action in one plane engenders an antagonist action to counteract the distortive effects on the glottis (see glottoregulation, 000) due to articualtive forces. The envelope actions in the other planes **equalize**, or **regulate** this distortion and so the 3-D structure of the tract tube is controlled. *See fig. f.1*

The trimeric tongue envelopes

fig. f.1

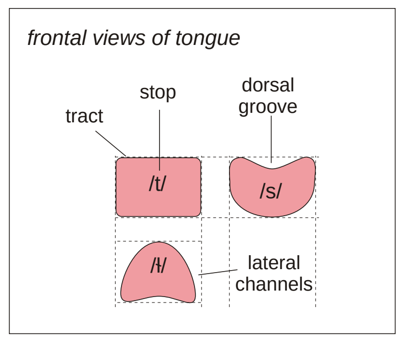


The mid-central or main anchor is common to all three envelopes.

f.2. The **lateral** subanchors and envelopes of the tongue serve in its lateral edge shaping. However, lateral modifications are not articulative, but part of tract shaping.

f.3. The **regulating/equalizing** antagonist function is, for continuous consonants, the agent which **correctively** opens an otherwise total occlusion to allow limited air passage. In this sense, the /s/, for instance is an alteration of the more basic masticatory stop /t/, modified by the superimposition of the linguo-dorsal air channel. Thus, a /t/ with particularly shaped air passage allowances is the sibilant /s/, and /ts/ is its fricative variant. With lateral air channels opened, a /t/ becomes the aspirated or lateralized /l/, while the normal /l/ is the variant of the back stop /k/. *See fig. f.3*

fig. f.3



f.4. Articulation and associated tract shaping is a function of **metaperistalsis,** where peristaltic action appears as the antagonist corrective action between consecutive tract segments. As the primary articulative shaping of the tongue occurs in one segment, the action of the subsequent one is antagonistic. *See fig. f.4*

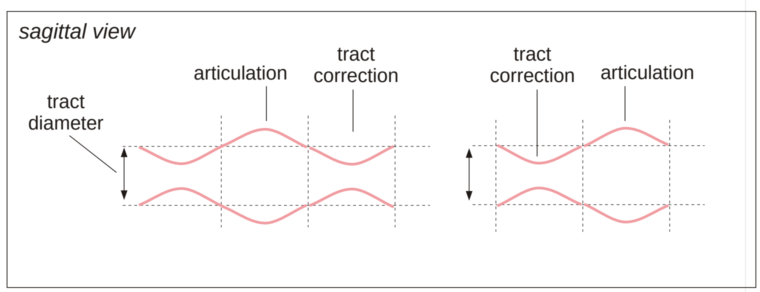


fig. f.4

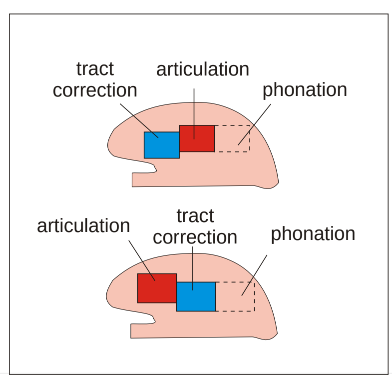


fig. f.5

f.5. In **full** speech the phonation and pneumatic pressure components are also combined with the articulation and tract formation, and their lingual anchor is always allotted to the third segment of the 3-segment (meta)peristaltic module. When the back segment is articulative, the front segment is tract regulative, and vice versa. The posterior segment in each case, is phonatory. *See fig. f.5*

f.6. Trimerism as metaperistalsis

The tripartite envelope setting is basically a utilization of the minimal **3-segment** mechanical unit of peristaltic action. In smoothly flowing peristalsis there is an action overlap of adjoining segments, whereby back segment B of the initial triplet does not simply end its action before the front segment F of the next triplet begins action, but rather, segment F starts off even as segment B terminates action. It is this **relay** of consecutive action that enables fluidity in speech, which is otherwise segmented. *See figure f.6.*

The various aspects of speech and voicing fit well into the trimeric system. The tongue is a tripartite organ, longitudinally divided into blade, body and base. Trimeric structuring is evident in the set of three vocal registers, the 3x3 divisions of the vowel quadrilateral, the front, central and back positions of phonemes.

Segmental relay

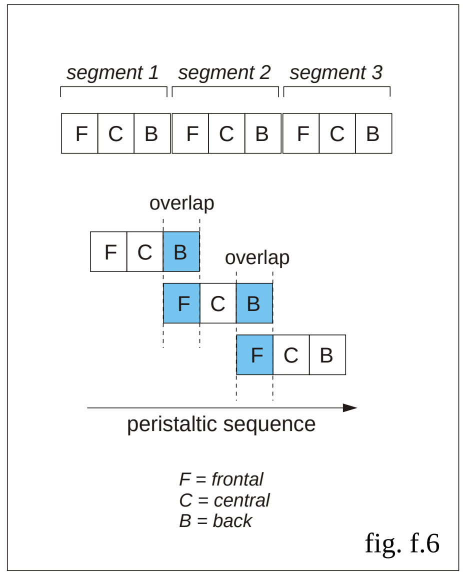


fig. f.6

f.7. Trimerism of the tongue explains how a **syllable** is framed. One segment is the articulator, another is the tract regulator and the third one is the phonator. That is, for a frontal CV syllable the first segment is the articulator (constrictor), with its second segment providing tract correction. Coming to the vowel, this second segment further modifies its tract expansion to form that of the vowel. The third segment is associated with hyo-laryngeal phonation. For a CV syllable with back consonant the order changes: the articualtion and tract correction occur, respectively, in the second and first segments. See fig. F.6.

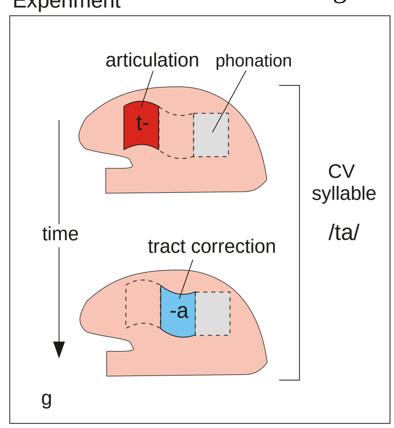
Note: One the musculature assigned to the lingual trimeric segments refer to p. 21, *I. Miscellaneous notes , note 4.*

f.8. Experiment

This can be **observed** if starting with a relaxed tongue we gradually generate segment by segment the syllable /ta (or /ti/). Articulation appears first, then follows the vowel and then phonation and each of the three lingual shapings is associated, respectively, with the front, mid and back tongue segments. The unity of the syllable frame is shown in that none of the functions is individually producible unless the other segment are also activated.

Experiment

fig. f.7



It can also be noted that in action with minimal energy a frontal stop, like /t/, is associated with the back positional variant of a vowel, whether it be a front, mid or backvowel. It can also be observed that in action with minimal energy a frontal stop, like /t/, is associated with the back positional variant of a vowel, whether it be a front, mid or back vowel.

Similarly, a back stop, like /k/, is paired with the frontal variant of a chosen vowel. This is also an aspect of metaperitalsis: producing a constriction and an expansion cannot occur in the same segment without increased effort and behaviors of increased complexity.

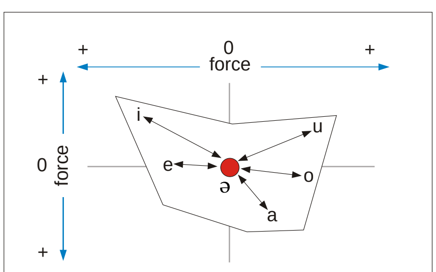
G. Anchor and envelope functions: mergers, anchor transformations

g.1 Anchor frame dynamics envelopes :

Anchors of articulation are generated by actively changing forces, and so are not static entities, but rather, temporary **dynamic** focal regions of a set of interactive movements and tensions. The activities of forces associated with an anchor and its framework are unique to a particular anchor and have limited, physiologically determined ranges and coactively changing directions, proportions, dimensions and energies. Therefore, their behavior, in terms of physical parameters, can be analyzed as performance **envelopes**. Anchors are the **mid-central** points of envelopes, maintained with minimal energy.
Anchor movement towards the border requires increased energy, in direct relation to the distance from the envelope center. Loss of energy moves the anchor back to its rest position.

g.2. Vowel envelopes

The cardinal vowel quadrilateral of a given language, for instance, is the **envelope** of the muscular behavior assigned to the anchor of the **specific vowel articulation anchor** of that language (4.1) **(sV)**. *See fig. g.2*



Vowel quadrilateral envelope

fig. g. 2

Note: When the (sub)anchors of specific vowels are superimposed on this general articulative frame, the neutral vowel anchor of the language occupies the minimal energy position, or central repose point, of the envelope, from which additional forces in various directions move and shape the tongue to generate the vowel anchors surrounding the central region.

Specific vowel anchors **(sV⚓s)**

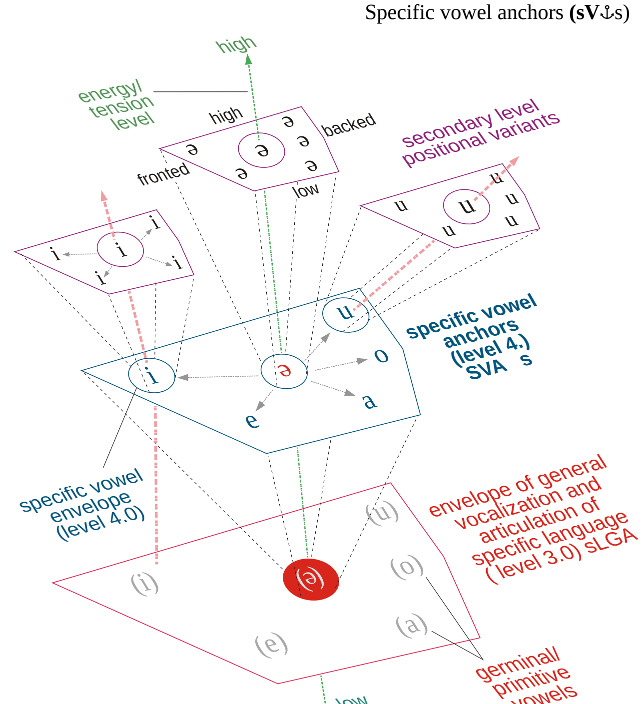


fig. g.3

g.4. Anchor systems - trimerism

A mid-central, or *main* anchor, residing in its envelope is the anchor of the resting state and it is the focal point of **two** additional sub-envelopes lying on the each of the horizontal and vertical axes passing through the mid-central anchor.
The sub-envelopes (as well as possible intermediate ones) are of higher energy and are less stable. As long as it remains the primary agent, even though its sub-envelopes overlap, the main anchor is dominant over four secondary or sub-anchors, located along the horizontal and vertical axes. *See fig. g.4.*

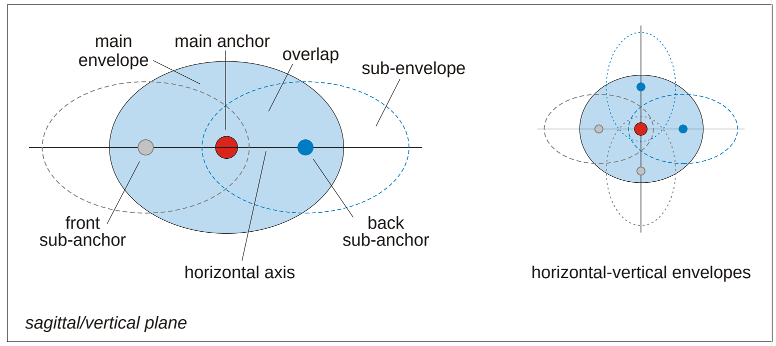


fig. g.4

Such **tripartite** envelope system is the basis for the **classification of vowels** into three groups, both horizontally and vertically, as front-mid-back and high-central-low vowels. The three voice **registers** as well as **tonality** likewise derive from similar tripartite mapping. Further subdivisions in each account for additional minor variants.

g.5. Active vs. passive anchor agency

An anchor can behave as either the active or passive (stable) agent in a particular mapping of the envelope and its anchors. For example, the role of the central anchor differs in the following two cases:

a. the central anchor is primary and stable, stabilizing within its envelope the active front and back anchors. This characterizes vowels.

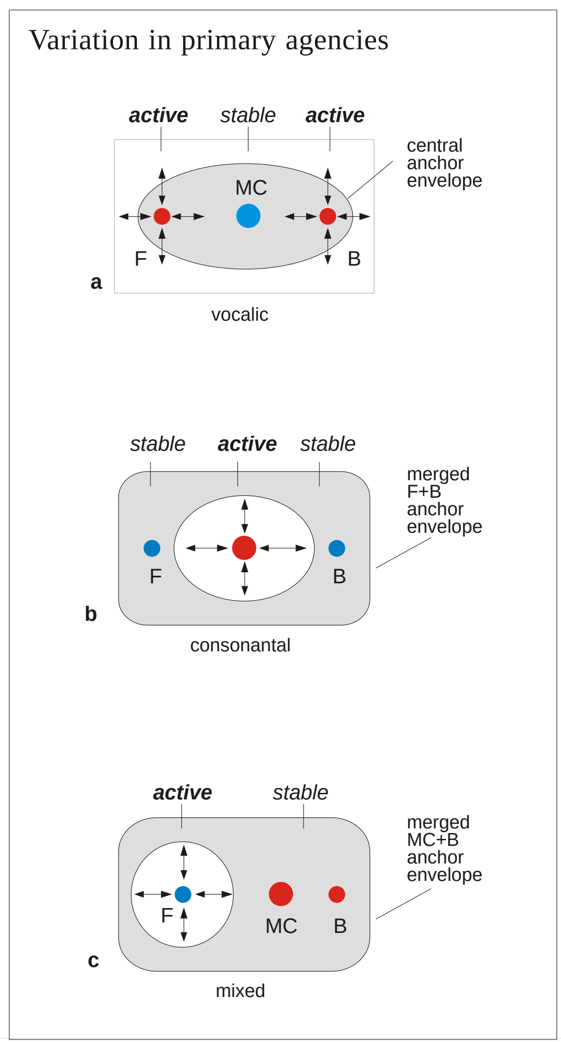
b. when the front and back anchors are primary and stable, stabilizing, within their united envelope, the movements of the active central anchor. This characterizes intervocalic consonants.

The central anchor is active within the combined envelopes of the front and back anchors, which are now the merged stable anchors.

c. The front anchor can be active when the mid-central and back anchors are stable. This characterizes initial vowels or consonants. *See fig, g.5.*

A. J. Sokoloff, in neurological study of the tongue refers to the active and stable anchors of the AMS as "active force movement" and "structural support", cf. Sokoloff (2004).

fig. g.5



g.6 Envelope manifolds - definition

Force moves within an envelope in the form of material tension. If a region of tension focused at the central anchor expands, the mass of forces reach the envelope limits as the force increases. At such a time a **glottoregulative** change, a **glide** or **clutch** switching, will enable passing the envelope limits and a new, larger envelope, of higher energy and less stability, will be generated around the same anchor. The shell or series of envelopes produced this way surround the given anchor and form its projected **manifold**. *See fig. g.6.*

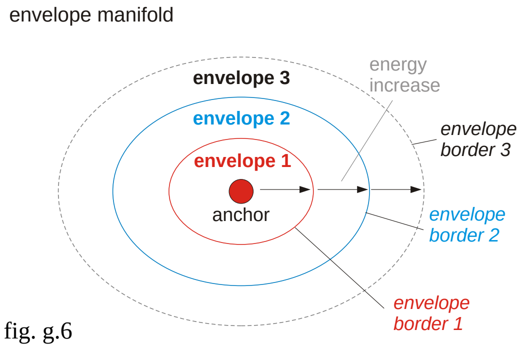


fig. g.6

g.7. Example of primacy transfer in envelope manifold

As an example of the primacy transfer of envelopes in the manifold:

1. *We* can start with an inner *envelope a*, comprised of the merged forces of a lingual anchor and the inner ends of the external muscles concurrent through the anchor. This anchor is the primary agent in relation to the surrounding shell of *secondary* anchors at the outer ends of the external muscles, which are its antagonists. The inner anchor and its surrounding antagonists together **form** the primary *envelope a*, which is typical of **consonantal** lingual anchors. *See fig. g.7a.*

2. If we then execute a glottoregulative change, i.e., a glide, clutch or mixed switching operation, to transfer dominance to the outer shell, up till now secondary agent anchor shell, then a **new** primary *envelope b* is generated, one which is still centered around the inner anchor, and is typical of **vocalic** anchors. *See fig. g.7b.*

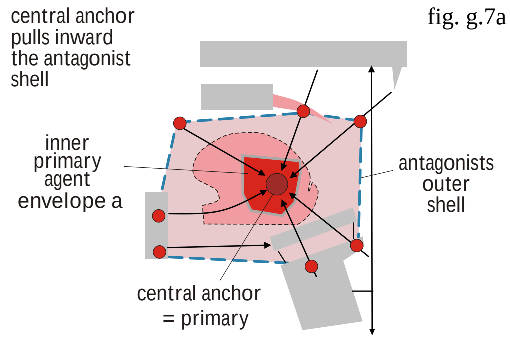


fig. g.7a

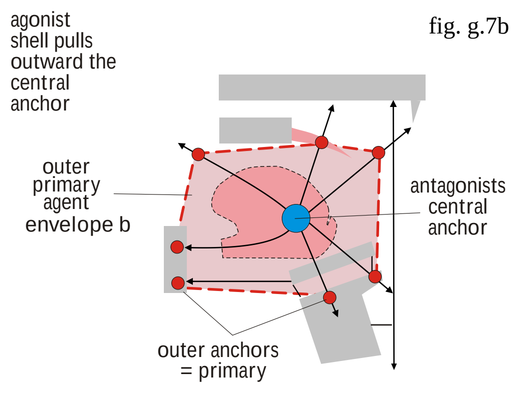
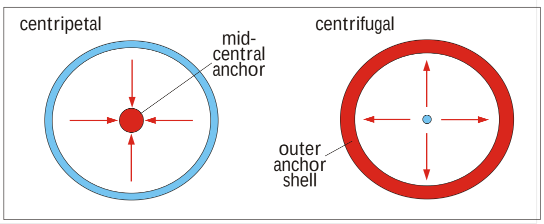


fig. g.7b

g.7a. Alternation of roles

Speech employs both the inner and outer envelopes: typically outer envelopes are primary agents for vowels and inner envelopes are primary for consonants. Through exchange of prime agency antagonists pairs alternate in their roles as active or stable anchors. With mid-central anchor dominance the forces are **centripetal,** while with dominant outer shell anchors the forces are **centrifugal.** Fluent speech proceeds through a pattern of **alternation** between inner and outer envelopes. This is, again, related to the metaperistaltic action of the upper visceral tract. See *fig. g.7a*. For **isolated articulatory** lingual anchors, i.e., those without phonation, centripetal and centrifugal primacies create, respectively, consonants, which are inherently constrictive and vowels, which are inherently tract expanding.

fig. g.7a. Alternating primacy fig g.8.



g. 8. Superimposition

In the process of anchor sequencing lower rank levels of anchors are always superimposed on higher ones. For example, over a vowel anchor and its envelope a **consonantal** anchor and its envelope can be mechanically grafted, or **superimposed**. This is accomplished by a unification, or merging, of anchors and a summing of their forces. The overlaid consonantal anchor/envelope is of a hierarchically lower rank, more energetic and therefore less stable than the underlying vowel. On completion of consonant articulation, the frame decays to the vowel frame because the higher "parent" (specific vowel) anchor, (4.1), **sV**) remains embedded or **enfolded** within the frame-works of its superimposed lower level consonantal "child" anchors.

More basically, the **general** anchor of a specific language (3.) is present in a "nuclear" form in all **specific** articulatory behaviors of that language, and serves as its **basis of articulation**.

The same process also accounts for the fact that in a given **syllable** the structural map, or quality of the syllabic vowel remains enfolded/deep within that of its consonant(s).

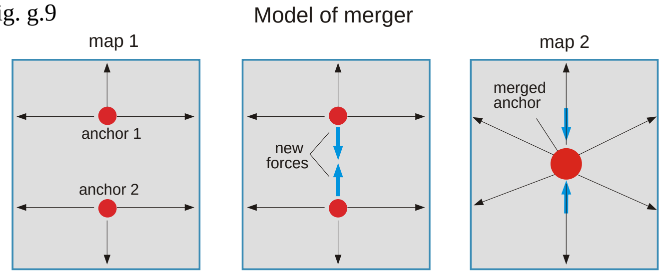
Note: in verse rhyming the re-emergence of an **enfolded** latent syllable within a phrase framework appears to be a physiological aspect of the appeal of rhymes.

g. 9. Mergers

Merging, or uniting, of forces, an established notion in physics, is the tool interaction in the anchor matrix of speech. During **superimpositions**, a temporary unification or **merging** of two or more distinct anchor frames takes place. The vocalic and consonantal nodal frameworks of a syllable cannot act independently because they are parts of a whole. Their two anchors have **merged** into a single combined anchor for the duration of the articulation, yielding a combined performance of the two coactive anchors and their summed forces. *See fig. g.9.*

Mergers are essential functions in unified, dynamically optimal anchoral behavior. In ongoing conversation the entire hierarchical series of anchor levels is in a state of continuously changing mergers as phrases, or the full speech mode itself, are entered of exited. Simultaneously, ongoing speech also goes through a series of phonetic/articulative mergers as it proceeds. This is one source of the difficulties in analyzing speech.

fig. g.9 Model of merger



g. 10. Masking

The hierarchically simultaneously superimposed merged anchors and their force envelopes in actuality overlap, forming a dense, layered, 3-dimensional structure, which **masks** and distorts the original architectures and positions of the essentially discreet frameworks. Distinguishing the variously ranked layers of the anchor frameworks makes it possible to describe speech production.

Once specific functions are isolated through appropriate experimental conditions the underlying structure of speech can be clearly observed.

g.11. Anchor transformations

In the speech process different phonemic anchors sequentially come into action. How these exchanges occur is a fundamental function of anchoral mechanics. (*For details see Foundations, Chapter 000*). Such transformations (or anchor switchings), are regulated by glottoregulation and are accomplished by means of :

a) a fluid **glide**, where respiration is unobstructed and continuous, *see fig. g.11a.*

b) a **clutch-**controlled switching, where re-spiration is blocked to various degrees by glottal closure during the anchor change, *see fig. g.11b.*

c) mixtures of the two in various proportions.

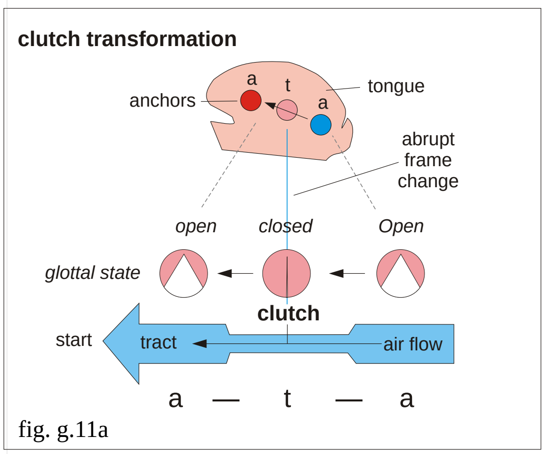


fig. g.11a

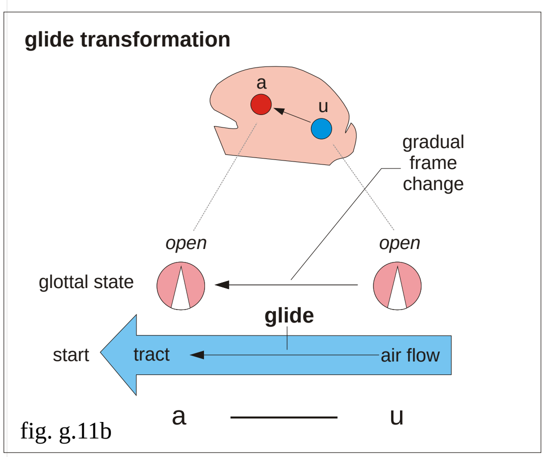


fig. g.11b

Note 1: Syllabification is a process of clutch-controlled switching between consecutive vocalic anchors. It is the clutch closure that separates syllables. Glottoregulation, or the mechanics for the clutch mechanism, is not described here. Syllabification is a manifestation of metaperistaltics and is inherent in speech simply because the peristaltic behavior the upper visceral tract consists of sequential opening and closure of segments.

Note 2: Whereas consonants are occlusive, generated by varying modes of air-tract closures and can only be created by, or connected through clutch-actions, vowel anchors can transform between each other in two ways:

a) Through **glides**.

For instance, in /i-o/ (Eng. "leo") the initial /i/ anchor frame transforms to /o/ **fluidly**, without closure of the tract. However, this is only partly true since a noticeable partial glottal and tract constriction occurs going from the /i/ to /o/. It is not the self-standing, primary /o/ anchor that appears during the /i-o/ transformation, but, instead, a secondary /o/ (sub)anchor generated in the /i/ frame is superimposed on the initial, or primary /i/ frame substrate. The superimposed /o/ carries latent within its map that of the initial /i/ substrate. The higher energy/tension state of this superimposition is the cause for a degree of constriction in the air channel. An independent /o/ is gene rated with less tension.

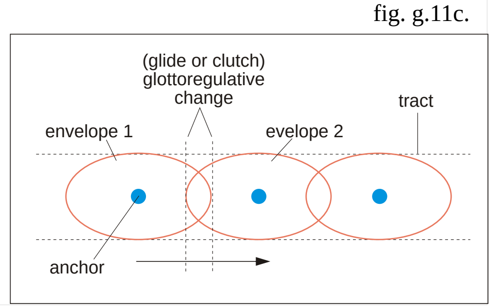
This is shown by the fact that the production of a stream of continuous vowel glides, or diphthongs, like /i-o-i-o-.../, during a single exhalation in normal breathing, without pre-filling the lungs with air, and without any glottal stictures has a reasonable comfort limit on the order of c. 6-7 diphthongs, after which the air supply runs out. There is, however, more air available, but only after exectuting a glottoregulative clutch closure.

b) Through **clutch-controlled** switching.

In contrast to employing glides, producing the same two vowels in the form of consecutive syllables separated by **glottal strictures**, (/i/, /o/, /i/, /o/...), has a higher comfort limit, during a single exhalation, on the order of c. 15 or more syllables. Syllabification is not only a tool of semantic encoding, but is also a device built into the vocalization mechanism to optimize the coactivity of

In the process of meta-peristalsis glottoregulative transition occurs as the passage between segments. See fig. g.11c.

fig. g.11c.



H. Miscellaneous notes:

Note 1: A particular merger takes place when **mastication** is combined with **speech**. The anchors of mastication and speech are adjacent structures, and so summing of their forces requires minimal effort. Their frameworks are similar; both produce lingual and mandibular movements and tract shaping.

This merged state allows neither effective speech nor mastication, but it is a position from which rapid alternation between speaking and eating is possible. These two anchors are hierarchically adjacent and easily converted because speech is built on mastication as well as on vocalizing respiration.

Note 2: The basic anchor framework of **singing** is produced from a merger of the general vocalizing anchor (1.) and the first oral respiratory anchor (0.1). (Cf. speech is a (0.0) + (0.1) merger.**)** This is reflected in the great significance of the respiratory function in singing technique. Singing combines vocalization and articulation as well as maximized oral tract and outward radiation enabled by 0.1. Verbal singing additionally superimposes the articulatory frame over this merger.)

Note 3: Anchor mergers at a high rank (levels 2.1; 2.2) supply th**e** basis of phonetic evolution, as in current or historical **sound shifts**, etc. The merger of general anchors of two languages or dialects at a high level has a "leverage advantage", causing significant changes in the behavior of the resulting merged articulative mechanism. Thus, besides through chronological evolution of phonology and grammar, language is also changed by influence of anchor mergers (or pronunciation) of languages brought together through historico-demographic causes.

Note 4: The **extrinsic** lingual muscles activating the trimeric segmentation of the anterior 2/3 tongue are illustrated in figure *h*. The frontal, central and back segments are powered, respectively, by:

a) frontal (segments of) the superior and inferior longitudinals, plus the frontal genioglossus;

b) mid superior and inferior longitudinals, plus the palatoglossus segment within the tongue, plus the mid genioglossus, plus the chondroglossus;

c) the back superior and inferior longitudinals, plus the palatoglossus (vertical), plus the hyoglossus.

The chondroglossus has generally been seen as part of the hyoglossus, having no independent function. The trimeric structure of the tongue assigns a distinct role for this muscle.

The functions of the transverse and vertical **intrinsic** tongue musculature, divisible into front, mid and back segments, is obvious and need no indication.

Musculature of lingual trimeric segments

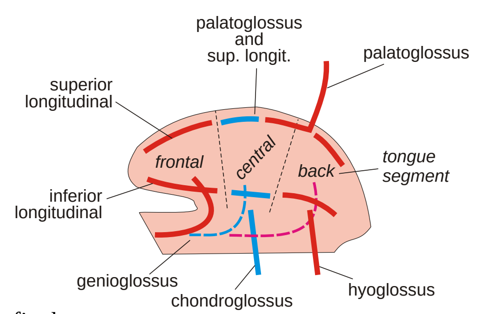


fig. h.

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Citations on monadism, p. 3

1. For such monadic functioning cf. Hiiemae and Palmer (2003): "Folkins and Kueh [1982] advance the concept of ‘bidirectionality’, in which they recognize that movement in one part of the system affects all the others. “

2. A. J. Sokoloff, in an article dealing with the neural behavior of the tongue, describes lingual monadic action in the following:

"The activation of any motor unit with tongue body presence can influence tongue shape and hence tongue movement. Because muscle fiber orientations vary with tongue shape, the mechanical effect of a motor unit (or entire muscle) is dependent on the integrated activity of all other tongue motor units. Multiple muscles work in concert to provide both the structural support and the active force for tongue movement."

(A. J. Sokoloff, *Activity of tongue muscles during respiration: it takes a village?* J. Appl. Physiol. 96: 438-439, 2004.)

3. The above terms "structural support" and "active force movement" appear to stand for the active and stable anchor in AMS.

4. Reference to UV monadism is made by Seikel (in Anatomy and Physiology for Speech and Language, 1977, p. 368) paraphrasing Karl Lashley (1951): ”the articulatory system is not a set of sleeping muscles waiting to be activated, but is rather a set of dynamic structures under continuous activation”.

Center of mass — definitions

1. That point of a material body or system of bodies which moves as though the system's total mass existed at the point and all external forces were applied at the point. (Sci-Tech Encyclopedia: Center of mass)

2. The center of mass is the location where all of the mass of the system could be considered to be located.

* For a solid body it is often possible to replace the entire mass of the body with a point mass equal to that of the body's mass. This point mass is located at the center of mass.(http://www.ac.wwu.edu/~vawter/PhysicsNet/Topics/Momentum/TheCenterOfMass.htmlCenter of Mass.)

3. The point in a system of bodies or an extended body at which the mass of the system may be considered to be concentrated and at which external forces may be considered to be applied. (Http://www.answers.com/topic/ center-of-mass?cat=technology).

4. The point at which all the mass of a body may be considered to be concentrated in analyzing its motion. The center of mass of a sphere of uniform density coincides with the center of the sphere. The center of mass of a body need not be within the body itself; the center of mass of a ring or a hollow cylinder is located in the enclosed space, not in the object itself. (Columbia Encyclopedia: center of mass).