

Ball et al. (2010). Phonology for
Communication Disorders, New York:
Psychology Press, pp. 145-162

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ARTICULATORY PHONOLOGY

INTRODUCTION

Articulatory phonology is considerably different from many of the other theories discussed in this book, as it is so heavily grounded in the physical act of articulation. The theory's architects, Browman and Goldstein (1986), insist that phonological description should be organized around articulatory activity, and hence bring phonetics and phonology closer together. Browman and Goldstein insisted on a very phonetic model of phonology, and so assumed gesture to be their phonological prime, that is, their smallest unit of phonological description (for this reason, the theory is sometimes referred to as gestural phonology). Crucially, the gesture is considered to be an actual articulatory event, with inherent duration. This is quite unlike the abstract, atemporal units of more traditional, feature-based accounts of phonology. Using this approach, Browman and Goldstein were able to offer a very rich, albeit powerful, theory of how speech is organized. This has significant implications for the way in which lexical contrasts, phonological processes, and natural classes can be expressed and understood. Indeed, much of the appeal of articulatory phonology is a direct result of its phonetic grounding. Furthermore, while theories such as autosegmental phonology (Goldsmith, 1976) have tended to analyze such phenomena as harmony and morphophonological alternations, articulatory phonology has been readily applied to the less mainstream, and arguably more challenging, areas of connected speech processes (Browman & Goldstein, 1990) and speech errors (Browman & Goldstein, 1992). Such applications undoubtedly serve to ease the transition of the theory's principles to the field of speech-language pathology.

This chapter outlines the background to the theory of articulatory phonology and considers some of the arguments for assuming that phonology is organized around concrete phonetic events. We will also draw your attention to the key differences between the gesture and its alternative, the feature, and consider the implications for assuming one over the other. Applications of a gestural account to speech disorders are then considered, and you may well find that the theory of articulatory phonology is among the more appealing approaches to phonology discussed in this book.

THE GESTURE AS PHONOLOGICAL PRIME

Phonology is distinct from phonetics in that it is the study of how individual languages combine a finite set of primes in order to form the lexical items of the language. This set of primes are those units that, when alternated, can bring about *lexical* change, not simply acoustic change. Models of phonology differ in what they assume to be the prime. Traditionally, the segment or phoneme has been the unit of analysis. Phonologists sought to define the set of contrastive phonemes in a language, claiming their combinatorial nature allowed for the formation of each and every word of the language. Like the splitting of the atom, however, the internal structure of the segment became of interest, and the notion of the distinctive feature emerged (Jakobson, Fant, & Halle, 1952; Jakobson & Halle, 1956; Chomsky & Halle, 1968). More recently, phonologists working with nonlinear representations have argued for an internal structure of these subsegmental features, as in the movement of feature geometry (Clements, 1985; Sagey, 1986).

Articulatory phonology addresses the problem of phonological organization from a phonetic perspective, and proposes the notion that "phonology is a set of relations among physically real events" (Browman & Goldstein, 1992, p. 156). These real events are called gestures in articulatory phonology, and constitute the prime of the theory. They are neither feature nor segment, but represent "the formation and release of constrictions in the vocal tract" (p. 156). The gesture is distinct from the feature in a number of ways, and yields quite a different approach to phonological analysis. In the sections that follow we consider the fundamental properties of the gesture.

The Articulatory Nature of Gestures

Broadly speaking, a gesture is the formation of some degree of constriction at some place in the vocal tract. In this sense, the gesture is substantiated through articulatory activity. Distinctive features, on the other hand, are properties of a segment that are responsible for phonological contrast. They are atemporal and are defined in a present or absent manner. The gesture is defined using *task dynamics* (Saltzman & Kelso, 1987; Saltzman & Munhall, 1989). Task dynamics is an approach to describing goal-oriented systems. Specifically, in humans, such goal-oriented behavior is observable in the skilled, coordinated movements used in such acts as reaching and, crucially, speaking. Articulatory phonology uses the principles of task dynamics to define gestures according to a series of *tract variables*. A tract variable defines one element of the formation of a constriction in the vocal tract. The tract variables (lip protrusion, lip aperture, etc.) and the articulators that are involved in conducting them (upper and lower lips, jaw, tongue tip, etc.) are shown in Table 12.1.

Gestures in articulatory phonology are defined according to their effect on a set of the tract variables in Table 12.1. Related tract variables begin with the same letters, yielding five *tract variable sets*: lips, tongue tip (TT), tongue body (TB), velum (VEL), and glottis (GLO). For each tract variable set, a series of parameter values is set. For example, if a gesture involves the tongue tip (TT), we need to specify both the location of the constriction (CL) and the degree of the constriction (CD). Alternatively, if a gesture involves nasality, we need only specify the degree of constriction for the velum, as the place of constriction is self-evident.

Despite the introduction of such terms as *tract variable* and *gesture*, nothing particularly remarkable has so far emerged about articulatory phonology. Rather, it seems speech is being defined according to the movement of a series of articulators—explicitly,

Table 12.1 Tract Variables and Articulators

	Tract Variables	Articulators
LP	Lip protrusion	Upper and lower lips, jaw
LA	Lip aperture	Upper and lower lips, jaw
TTCL	Tongue tip constrict location	Tongue tip, tongue body and jaw
TTCD	Tongue tip constrict degree	Tongue tip, tongue body and jaw
TBCL	Tongue body constrict location	Tongue body, jaw
TBCD	Tongue body constrict degree	Tongue body, jaw
VEL	Constriction degree	Velum
GLO	Constriction degree	Glottis

Source: Adapted from Browman & Goldstein (1992, p. 157).

the specification of degrees of constriction being formed at the lips, tongue tip, tongue body, velum, and glottis, with the location of this constriction being given for the tongue tip and tongue body. It is worth noting, though, that gestures are consistently defined using articulatory information. Features, on the other hand, often make use of acoustic information. The feature [\pm strident], for example, specifies the presence or absence of stridency in a sound, a purely acoustic property. For speech-language pathologists, the gestural approach seems advantageous, as articulatory disorders are consistently defined according to abnormalities in the act of articulation, not in the acoustic properties. However, Clements (1992, p. 183) does question the significance of this difference, concluding that it is nonessential in nature. In support of this, the articulatory correlates of such features as [strident] are made explicit in the distinctive feature literature (e.g., Halle & Clements, 1983).

The Parameter Settings of Gestures

As you'll recall from Chapter 4, the features of *The Sound Pattern of English* (SPE) are binary in nature.* For example, the feature [\pm nasal] indicates either the presence or absence of nasality in a segment. As a result, oral consonants such as /p, d/ are specified as being [-nasal], while nasal consonants such as /n, m/ are specified as being [+nasal]. Rules can subsequently alter the feature for a segment to account for surface forms, as in the nasalization of vowels in English. In articulatory phonology, we find a quite different state of affairs. Gestures are defined not just by the presence of some tract variable, but are specified for how the gesture is achieved. That is, constriction degree, constriction location, damping, and stiffness are all specifiable along a continuum.

Browman and Goldstein (1992, p. 159) use the term *parameter* to refer to the differences in the way gestures can be articulated. For example, consider constriction degree (CD). It is not sufficient to state that there exists a degree of constriction at some place in the mouth. Rather, we need to specify how much constriction is present. The accepted parameter distinctions are fivefold: CD: clo(sed), CD: crit(ical), CD: mid, CD: narr(ow), and CD: wide. This particular parameter allows us to express differences between stops, for example, which have complete closure, and fricatives, which have a critical constriction degree that is close enough to create turbulence. The values mid, narrow, and wide are used for the differentiation of approximants, close vowels, and open vowels. Such an

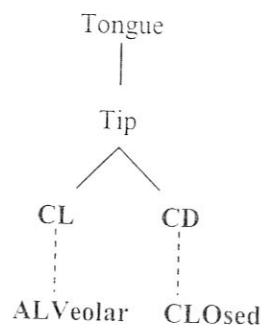
* Recall, though, that Ladefoged (1971) did subsequently develop a system of distinctive features that used both binary and multivalued features.

approach leads us to analyze the difference between the English words *tad* and *sad* as being simply a difference in the parameter value for the first TT gesture (closed in *tad* and critical in *sad*). In contrast, the difference between the words *tap* and *gap* involves the same constriction degree but uses different tract variables (TT and TB). This, you should note, is a much richer approach to accounting for lexical contrasts than merely positing a change in segment (lexical contrasts in articulatory phonology are discussed further below).

If a difference in constriction degree is parameterized at the phonological level, it follows that other gestures should select a particular parameter setting. Constriction location (CL) selects from the following parameter values: CL: lab(ial), CL: dent(al), CL: alv(eolar), CL: palatal, CL: velar, CL: uvula, and CL: phar(yngeal). Equally, stiffness can be used to contrast vowels from glides, while damping can contrast flaps from stops (Browman & Goldstein, 1992, p. 159).

A gesture, then, if present in the articulation of a word, needs to be specified for certain articulatory parameters. We can schematize this as in (1), where the makeup of a complete closure at the alveolar ridge is shown (as in the onset to the English word *tip*).

(1)



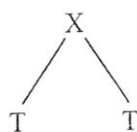
You should notice that the representation in (1) is not dissimilar to the sort of feature geometries we introduced in Chapters 5 and 7. In feature geometric terms it specifies the place and manner of the articulation of an individual segment. If (1) were to be associated with a particular slot on the skeletal tier, then it would be no different than describing a segmental unit occupying a single timing slot. However, in articulatory phonology representations are not formed using timing slots, as gestures vary in their individual duration. This property of the theory is crucial to understanding its potential for accounting for graded phonological variation.

The Internal Duration of Gestures

A crucial difference between articulatory phonology and feature-based systems is the fact that gestures have internal duration. This allows gestures to vary in how they co-occur. Crucially, it means gestures can overlap not at all, partly, or completely, and are perhaps the element of articulatory phonology that is responsible for the incredible richness (or rather, power, in generative terms) of the theory. Such richness has been regarded as advantageous in nature, but also as being the Achilles' heel of the theory (see, for example, Steriade, 1990).

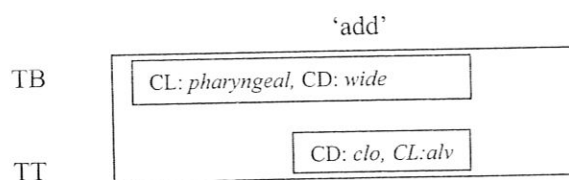
Recall from Chapter 7 the description of association lines in autosegmental phonology. They serve to indicate that two autosegments on two separate tiers of the autosegmental graph are articulated simultaneously. Moreover, they allow multiple autosegments on one tier to be mapped onto a single segment on another, as in, for example, the case of a single vowel being associated with two tonal segments (2).

(2)



In articulatory phonology we talk about the *phase relations* of different gestures, and the way they occur in time. Remember that a gesture is an actual event, and so it stands to reason that some gestures may take longer to reach a completion point than others. Equally, gestures will not always completely align with each other, and may well overlap. Take, for example, the representation in (3), which shows the gestures (along with their parameter values) for the tongue body and tongue tip tract variable sets in the production of the English word *add*. The tongue body gesture is the vocalic production, with a pharyngeal constriction location and a wide constriction degree. The consonantal gesture involves a closed constriction degree and a location of alveolar.

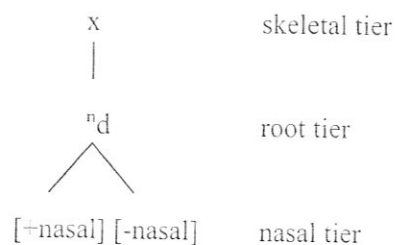
(3)



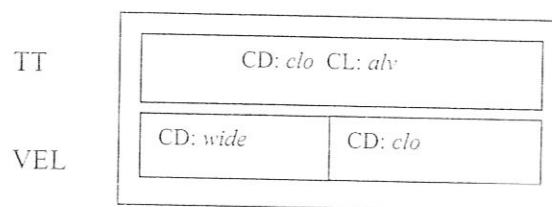
What is important to note in (3) is that the gesture for the tongue tip is only half the duration of the gesture for the tongue body. This is how representations are formed in articulatory phonology, and (3) is a portion of a complete *gestural constellation* (defined and discussed in the next section). Specifically, gestures are coordinated with each other at three possible points: the onset of movement toward the target, the achievement of the target, and the beginning of the movement away from the target (we will refer to these from now on as the *onset*, *achievement*, and *offset*, respectively). In (3) the achievement of the TB gesture coincides with the onset of movement toward the TT gesture. Consequently, these two gestures are in a state of *partial overlap*. Browman and Goldstein (1992) have suggested that gestures can overlap minimally (i.e., not at all), partially (as in (3) above), or completely (in cases when the onset of movement toward the target of two distinct gestures coincides). What is sometimes unclear in the articulatory phonology literature, however, is the degree to which *partial overlap* can vary. The representation in (3) exhibits partial overlap commencing at the halfway point of the vocalic gesture. If we are to permit partial overlap to begin at any stage in a gesture, then the number of phonological contrasts being predicted due to overlap is simply immense. Specifically, it is in stark contrast to the more constrained approach taken in nonlinear phonologies.

Traditionally, mainstream phonology has been heavily concerned with the segmentation of the speech stream. A recent incarnation of generative phonology, the autosegmental model, did move away from this somewhat, but still posited sequences of segments at the root, with only the composite features of segments having the potential to spread across several phonemes. And even with this freedom of association, it was not possible for features to overlap with each other only partially. For example, consider the case of prenasalized stops we discussed in Chapter 7, where an autosegmental representation would be similar to that shown in (4), and a possible gestural account is shown in (5).

(4)



(5)



In autosegmental phonology, autosegments could be either co-registered or not. We can call this a purely *categorical* approach to representation. In articulatory phonology, gestures can vary according to the degree to which they overlap, offering a *gradient* approach. In doing so, articulatory phonology aims to capture the *syntagmatic* aspect of speech.* That is, the phonetic properties that span a word or utterance. The inventory of gestures serves the purpose of capturing the *paradigmatic* aspect of speech, the interchangeability of its subparts. In this respect, the aims that underpin articulatory phonology can be directly related to those of the theory of prosodic analysis (discussed in Chapter 9), where capturing the syntagmatic and paradigmatic aspects of speech were of equal importance (Robins, 1957, p. 191).

While the advantages of positing gestural overlap are abundant, it has been a property of the theory that has drawn some criticism. In a comparison of the gesture and the feature, Clements (1992, p. 185) questioned the need for such potential richness of representation. He argued that the "system predicts the existence of many more types of lexical contrasts than are actually attested." It is debatable, however, whether Clements' point is well grounded. He claims that the three potential linking points of

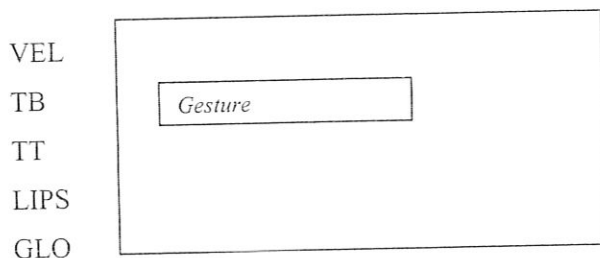
*The distinctive between syntagmatic and paradigmatic properties of language was made by, among others, Ferdinand de Saussure (Anderson, 1985, p. 186) and adopted by the likes of Firth (1937). You may encounter the terms *structure* and *system* used interchangeably for paradigmatic and syntagmatic (Clark & Yallop, 1990, p. 386).

gestures—the onset, achievement, and offset—yield nine different ways in which two gestures can be combined, not three, as Browman and Goldstein claimed. However, if the onset of one gesture coincides with the onset of another, that is the same scenario as if the offset of two gestures coincides, that is, complete overlap. Moreover, Browman and Goldstein make explicit the point that articulatory phonology is intended to be able to explain both the categorical (lexical contrasts, for example) and the gradient properties of speech (language change, or connected speech processes, for example). If the latter is to be successful, then the overlapping of gestures is an essential property of the theory. This is especially true in the treatment of language acquisition and clinical cases, as the next section moves on to explore.

REPRESENTATIONS IN GESTURAL PHONOLOGY

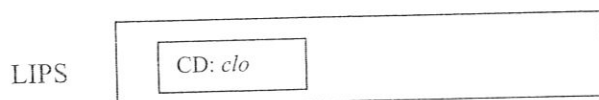
It is by using a *constellation* or *score* that the gestures of articulatory phonology are represented. A bare constellation is shown in (6), with only an abstract gesture filled in. Running vertically down the left are the five tract variables: velum (VEL), tongue body (TB), tongue tip (TT), lips, and glottis (GLO).

(6)



For any given word, a constellation will be formulated with the specific gestures appearing inside the box next to the appropriate tract variable. For example, if a closing of the lips takes place (as in a labial consonant), a gesture will appear on the LIPS column. In the articulatory phonology literature it is common for a box to be used. Enclosed in this box will be the parameter values for this gesture. The lip-rounding found in the segment /b/, then, would be represented as shown in (7).

(7)

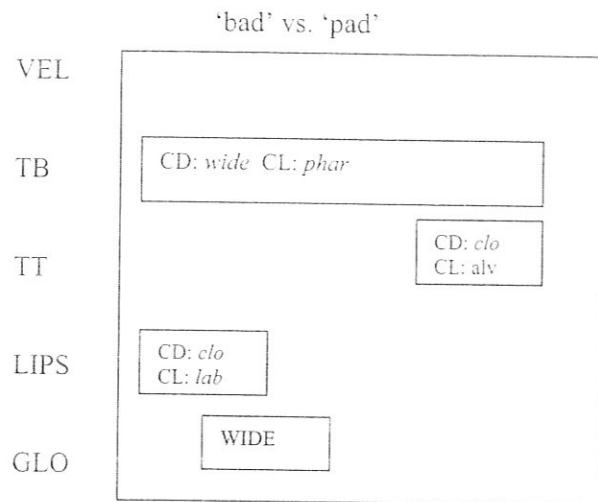


Categorical Contrasts in Articulatory Phonology

Using such representations, lexical contrasts can be expressed easily. Specifically, Browman and Goldstein state that words can be contrastive due to (1) the presence or absence of a gesture, (2) differences in parameter settings of two identical gestures (e.g., constriction degree of a tongue tip movement toward the alveolar ridge), (3) differences in how the same set of gestures may be organized, and (4) differences in the duration of gestures. We will exemplify each with a commonly occurring lexical contrast from English.

The presence or absence of a gesture is a simple contrast. An example is the distinction between *bad* and *pad*, which sees the addition of a glottal gesture to *pad* to achieve the effect of aspiration (shaded in (8)).

(8)

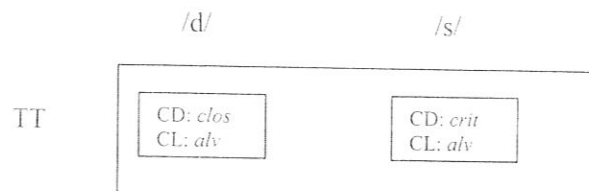


EXERCISE 12.1

Draw a gestural score to show the Hindi word [b'uk^h] *hunger*. The [u] vowel is represented by CL: velar; CO: nar.

The second potential contrast comes about when a parameter setting is altered. As discussed above, this allows for the distinction between such words as *tad* and *sad*, whereby *tad* selects a constriction degree value of *closed* and *sad* selects one of *critical*. Other than this, the two words are identical in terms of number and duration of gestures, as shown in (9).

(9)



Distinction 3 involves differing organizations of the same gestures. A simple example is the pair of words *bid* and *dib*. Here the two consonantal gestures will be in the opposite positions in either word. You should note that this distinction does not apply to all words that would be traditionally dealt with as consisting of the same segments, but in differing orders. For example, *mad* and *damn* comprise the same phonemes, but in the

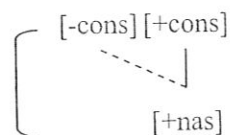
latter word there would be an additional distinction in that the gesture causing nasality on the velum column would be longer than in the former. This contrast then encompasses both distinctions 3 and 4. A contrast that utilizes distinction 4 alone is exemplified by the difference between long and short vowels.

Adopting the gestural framework could have implications for the way phonological therapy is carried out. Traditionally such therapy has focused on the phoneme, and attempted to remedy any phonemes that are erroneous or absent in a system (van Riper, 1978). Using the system described above, speech is composed not of segments, but movements, and what we have traditionally thought of as minimal pairs may vary to the extent in which they themselves vary. Furthermore, the same segment in initial position may not have the identical articulatory characteristics as in final or medial position, due to the overlapping of gestures. This also has implications for therapy techniques.*

Gradient Contrasts in Articulatory Phonology

Perhaps most salient about work in articulatory phonology is a clear move away from a strictly segmental view of speech, and it is the potential for the overlapping of gestures that makes the gestural score so adequate for this endeavor. To explore this potential, let us consider the nasalization of vowels in English. It is well known that vowels preceding a nasal consonant become at least partially nasalized themselves. A classical SPE style account of this phenomenon needs to specify the change of the vowel's feature [-nasal] to [+nasal] when it is preceded by a nasal consonant. This, of course, fails to make explicit the fact that it is the same property of the consonant that is present in the vowel (the lowering of the velum in articulatory terms). A modern featural account remedies this somewhat and will typically indicate the spreading of the feature [+nasal] from consonant to vowel, as shown in (10).

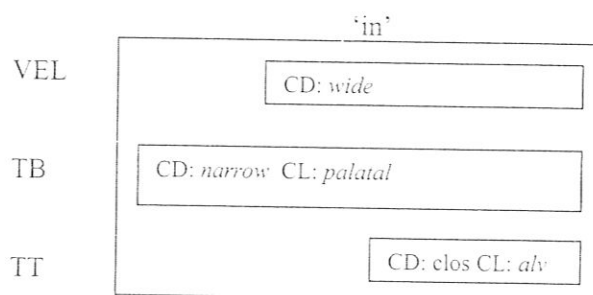
(10)



In articulatory phonology the spreading of nasality can be expressed effectively and succinctly by exploiting the potential for gestures to overlap. In the score in (11) a representation for the word *in* is shown. The gesture for the opening of the velum begins slightly before that for the movement of the tongue tip, thus indicating the nasalization of the vowel.

* Note that Grumwell (1986) endorses an approach to phonological intervention that emphasizes the importance of treating sounds by position rather than as individual units. Equally, the theory of prosodic analysis demands that sounds from different parts of a word should be analyzed as belonging to different systems. We call this notion polysystemicity.

(11)

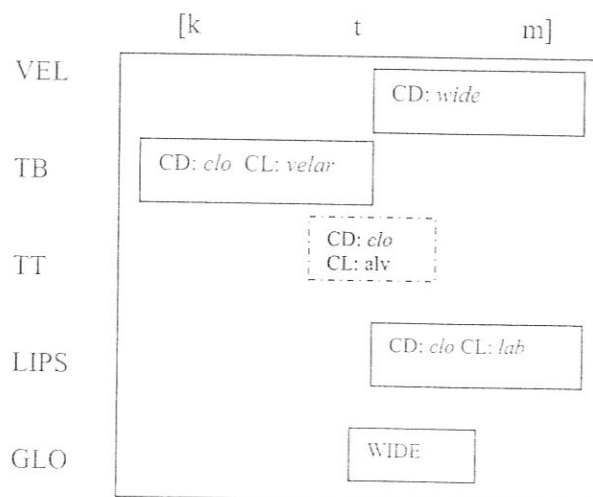


EXERCISE 12.2

What would a gestural score for the English word *man* look like? Pay particular attention to the gesture corresponding to nasality.

A second example of graded phonological variation due to gestural overlap was cited by Browman and Goldstein (1990) and involved the notion of a gesture being *hidden*. Analysis of two contextually different productions of the phrase *perfect memory* was carried out, one where the phrase was placed in a word list and the other where the list was spoken during fluent, connected speech. Perceptually, it seemed the [t] of *perfect* was deleted when the phrase was spoken in fluent speech, but was intact when the phrase was spoken in a word list (when in a word list, the two words *perfect* and *memory* would be divided by an intonational boundary). This is a commonly reported occurrence in the literature concerning the phonetics of connected speech (Clark & Yallop, 1990, p. 90; Ball & Müller, 2005, p. 259), usually being referred to as consonant elision. Interestingly, it is typically claimed that such elision occurs at the boundary between a word final consonant cluster and a word initial consonant cluster. However, Browman and Goldstein found (using x-ray evidence) that the stop closure for [t] was present but nonaudible on account of it being fully overlapped, or hidden, by other gestures, specifically, the offset of [k] and the onset of [m]. This is schematized in (12).

(12)



As (12) shows, the gestural score has many gestural configurations at the word boundary. The result is that the gesture for the alveolar closure (filled grey in the representation) is acoustically and perceptually hidden.

CLINICAL APPLICATIONS OF ARTICULATORY PHONOLOGY

Somewhat unfortunately, there is a distinct lack of work looking at clinical data from an articulatory phonology perspective. Kent (1997) partially attributed this gap to the then newness of the theory; however, even today work in clinical phonology has been dominated by the more mainstream optimality theory (see Prince & Smolensky, 1993; Bernhardt & Stemberger, 1998), which seems to have superseded articulatory phonology. This is regrettable, as the ability of articulatory phonology to provide concise accounts of graded phonological variation has been shown to be useful in clinical cases from child language development (Studdert-Kennedy & Goddell, 1995) to motor speech disorders (Weismer, Tjaden, & Kent, 1995; Kent, 1997) through to progressive speech degeneration (Ball et al., 2004). In this section we summarize the progress that has been made in each of these areas of work.

Language Acquisition

Browman and Goldstein themselves highlight the applicability of articulatory phonology to language development (1992, p. 176), and the theory's superiority over strictly segmental approaches to language acquisition has been argued in Studdert-Kennedy and Goddell (1995). Under this view language development is regarded as the differentiation and coordination of a set of basic gestures that emerge during the babbling stage of a child's life. Language acquisition is then a continuum of mastering these articulatory gestures. This accounts for the gradient development of language and the variability in production during the early stages of childhood. As gross gestures are still undifferentiated by the child, productions are less accurate with a reduction in the fine-grained contrastivity of the adult system. The ability to produce segment-sized units comes later in acquisition, as the mastery of gestures is completed.*

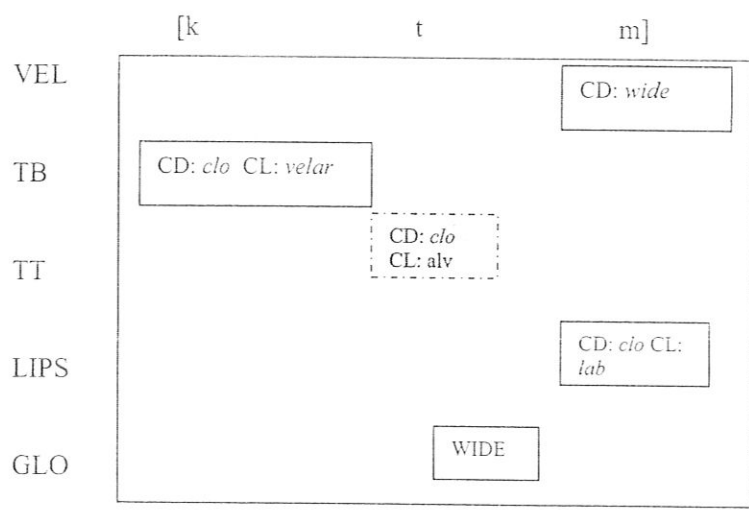
Hewlett and Waters (2004) have questioned the validity of this account, however, suggesting that the solely *articulatory* nature of articulatory phonology is problematic. They cite findings where the progression toward the production of the labiodental fricative /f/ passes through a stage where the child produces /s/. Hewlett and Waters insist that the child must be attempting to replicate the high-frequency turbulence associated with /f/ by producing the similarly turbulent /s/. Implicit in this approach is a perceptual component of language development, which articulatory phonology is seemingly lacking. Regardless, it seems the approach put forward in articulatory phonology is still more intuitive than a simple mastering of an inventory of phonemes, or distinctive features, or constraint ordering.

* This is in line with the view held by Bybee (2001) and other cognitive linguists, who regard segments as emergent properties. See Ball (2001) and Chapter 14 of this book for a discussion of cognitive phonology and clinical linguistics.

Motor Speech Disorders

Motor speech disorders are rarely dealt with using phonological theory, as the symptoms of such conditions as Parkinson's disease and Wilson's disease do not lend themselves well to the categorical, lexicon-centric approach favored by most phonological theories. Motor speech disorders typically present with graded effects to speech, rather than the complete loss or misuse of a particular segment, for example. Articulatory phonology, however, offers great potential for the characterization of such symptoms through the use of abnormal gestural phrasing relations. Weismer et al. (1995) consider the ability of articulatory phonology in handling such symptoms, and conclude that the theory can offer much. Articulatory slowness, for example, is quite easily handled by articulatory phonology via a process of lengthening the duration of gestural components. Equally, the process of segmentalization, where segments in words appear isolated, devoid of coarticulatory and assimilatory processes, is handled well via the reduction in the amount of gestural overlap. For example, a segmentalized production of the sequence in (12) is represented in (13).

(13)

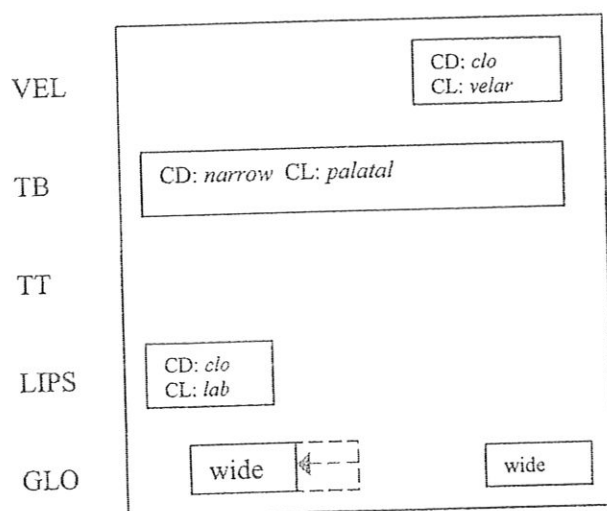


Progressive Speech Degeneration

It is fairly uncontroversial to say that a large proportion of the work in clinical phonology deals predominantly with developmental phonological/articulation disorders in children. For that reason, cases of phonological disorders occurring later in life provide interesting potential for theoretical exploration. Building on work in Ball (2003), Ball et al. (2004) provide a gestural account of the progressive degeneration (of unknown etiology) of the speech of a 63-year-old male. One of the markers of the degeneration was an inability to distinguish voiced and voiceless plosives, resulting in insignificant differences between the voice onset time (VOT) of either voiced or voiceless plosives. Specifically, the client averaged a VOT of 21 msec for the voiceless tokens and 18 for the voiced. In contrast, the authors report averages of 59.6 and 18.5 msec for the SLP. This is accounted for by positing a loss in the ability to control the

duration of the glottal gesture creating voicing. Specifically, the client significantly reduces the duration of this gesture, such that the crucial contrast between voicing and voicelessness is lost. This is represented in (14), where the arrow indicates the abnormally short duration of the glottal gesture. In articulatory phonology terms, we can call this gestural *sliding*.

(14)



Because degeneration of speech is often progressive in nature, the gradient nature of articulatory phonology is well suited to account for such change. A featural account could simply represent the loss of a feature (in this case the change from + to - [voice]) without recognizing that this change would be gradual and would not necessarily be an all-or-nothing phenomenon.

EXERCISE 12.3

Gestural phonology can also be applied to child speech disorders. Draw constellations showing the difference between target *booth* (/buθ/) and typical disordered child speech [bup]. How does the gestural score explain the changes here?

FURTHER READING

Articulatory phonology was introduced in Browman and Goldstein (1986) and developed further in Browman and Goldstein (1989, 1990) and Kingston and Cohen (1992). A complete overview of the theory can be found in Browman and Goldstein (1992). Gafos (1999) used the representations of articulatory phonology as the input for an optimality theoretic grammar. Task dynamics for the purposes of speech is discussed in Saltzman (1986). The theory has been compared to generative phonology in Clements (1992) and Steriade (1990).

Articulatory phonology has been applied to a large range of phenomena, including connected speech processes (Browman & Goldstein, 1990, 1992, pp. 171–176) child language

development (Studdert-Kennedy & Goddell, 1995), motor speech disorders (Weismer et al., 1995; Kent, 1997), and progressive speech degeneration (Ball et al., 2004).

REVIEW QUESTIONS AND STUDY TOPICS

Review Questions

1. According to articulatory phonology, what do the terms *gesture*, *tract variable*, *parameter*, and *gestural constellation* mean?
2. What is the difference between the syntagmatic and paradigmatic aspects of speech?
3. What are the three possible ways in which gestures can overlap?
4. What did Browman and Goldstein mean when they said they wanted to account for gradient as well as categorical change? What is an example of each?
5. What is gestural *hiding* and how is it related to the notion of connected speech processes?
6. How is language development regarded in articulatory phonology?
7. What is segmentalization and how might a gestural approach account for it?
8. What is gestural sliding and what can it be used to account for?

Study Topics

1. Carefully compare the chapters in this book on autosegmental phonology and articulatory phonology. Draw up a list of similarities and differences between the two. How much do you agree with Kent (1997, p. 248) when he says that articulatory phonology "embraces certain principles of autosegmental phonology"?
2. Use the list of phrases provided below and embed them first as part of a word list, and then in a series of sentences. Record a few of your friends saying the word list and then some other friends saying the sentences. Listen to the recordings and see if you can find evidence for gestural hiding occurring at the end of the first word.

passed by	finished work	cold night
next week	soft cushion	raised them
last night	East Texas	refused them
finished work	found them	old car