Phonetically Based Phonology

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The Phonetic Bases of Phonological Markedness

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Q & A

Q: If markedness constraints function within linguistic competence (innate and universal), how are the grammars of the individual languages structured?

A: OT: markedness constraints are ranked and violable. They are a set of highly general constraints which, through different **rankings**, govern the individual languages.

Q: What is the source of the individual's knowledge of markedness constraints?

A: This chapter: phonological constraints have their roots in the **shared phonetic knowledge** of the speakers of all languages. This shared knowledge on the physical conditions of production and perception creates **similar markedness constraints**, which results in similar grammars and generates **phonological typology**.

MARKEDNESS

Markedness vs markedness:

- markedness is used in a typological sense, to identify structures that are rare or systematically missing, like [–ATR] which is marked (retracting the tongue towards the back of the mouth requires a larger degree of muscular coordination and control).
- Markedness, with a capital M, refers to an element of a formal linguistic theory, as in OT, where the term markedness characterizes a constraint type (*Vnasal)

Markedness in OT is also sometimes related to the universal and innate constraints. Typological markedness denote patterns which are usually explained by the Markedness constraints.

Phonetically-based Markedness and OT

Phonetically-based markedness was first referred to in **Natural Phonology** (Stampe 1973) within SPE.
Natural Phonology suggests that the phonological patterns of a language are shaped by a set of innate, universal phonological processes. In this theory, "markedness" refers to the idea that some phonological features or patterns are more **difficult** or complex to produce or perceive.
In a rule-based framework, there must be multiple fixes, all of which address the same phonetic difficulty.

While OT says: **What is phonetically difficult is not necessarily difficult to fix**.

However, in OT, not all the constraints can be satisfied at once. Faithfulness and Markedness constraints might conflict; moreover, there are conflicts between different types of Markedness constraints (notably, those grounded in production vs those grounded in perception). So we can't expect the resolution of these conflicts to be uniform across languages.

Inductive (main approach to markedness): making a cluster of observations about known languages and extracting markedness laws according to those observations.
The markedness law may be:

- absolute (e.g., There is no initial system in which all obstruent combinations share the same value for voicing),
- implicational (e.g., The presence of syllabic [h] implies the presence of syllabic fricatives)
- a trend (e.g., If a nasal vowel system is smaller than the corresponding basic vowel system, it is most often a mid vowel that is missing from the nasal vowels)

There is an issue with the research strategy here. The number of conceivable typological observations is so vast that our results will be disorganized if we examine the data in arbitrary order, without a general conception of what makes a possible markedness principle.

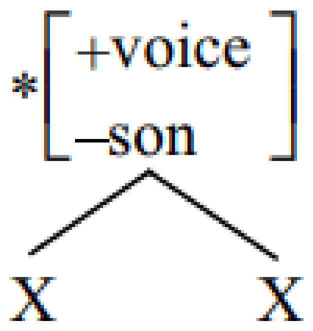
Deductive: hypothesizing general principles explaining why the markedness laws should hold.
The approach of this study to markedness is deductive, by asking: Are there general principles or properties that distinguish marked from unmarked phonological structures, and, if so, what are they?

Inductive and deductive approaches to the study of markedness

Markedness from phonetics: a constraint and its phonetic basis

An example of the deductive approach to markedness, which has its roots in phonetics:

In a number of languages, a constraint is needed that penalizes voiced obstruent geminates:

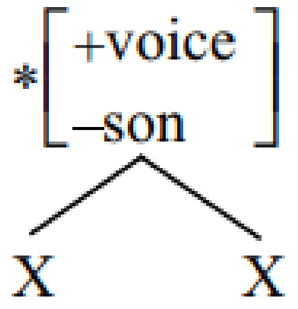


While no language bans just the voiceless geminates.
Thus, this constraint has a typological counterpart, this implicational law:

The presence of a voiced obstruent geminate in a given language implies the presence of the corresponding voiceless geminate.

From Phonetics to Grammar

Now we explore the hypothesis that some version of this constraint is universal and is inferable from generally available phonetic knowledge:



a. Facts of phonetic difficulty
b. Speakers' implicit knowledge of the facts in (a)
c. Grammatical constraints induced from the knowledge in (b)
d. Sound patterns reflecting the activity of the constraints in (c)

Facts about phonetic difficulty (a) and sound patterns (d) are obtainable from experiments (vocal tract modeling and descriptive phonological work). But the precise contents of (b) and (c) should be guessed at.

Some phonologists say that markedness scales and their knowledge (b and c) do NOT explicitly and directly relate to the phonetic difficulty (a)

However, this book indicates that there is evidence for a much closer connection between (a) & (b), and even (c) & (d)

A Direci mapping from (a) onio (b) (c) (d)

The case study: **Voicing in obstruents geminates**

- (a) the articulatory difficulties involved in sustaining vocal cord vibration in different obstruents
- (b & c) the ways in which speakers can encode knowledge of these difficulties in markedness scales.

a. Facts of phonetic difficulty
b. Speakers' implicit knowledge of the facts in (a)
c. Grammatical constraints induced from the knowledge in (b)
d. Sound patterns reflecting the activity of the constraints in (c)

(a) Two phonetic difficulties in producing the voiced obstruents geminates

1. the duration of oral closure (Di: ≺ Di)
2. the size of the cavity behind the oral constriction ([g:] ≺ [d:] ≺ [b:])

1. **duration:**

Active oral tract expansion (like tongue root advancement) is necessary to maintain airflow in an obstruent. And It is difficult to sustain the production of voicing in long obstruents.

So: Di: ≺ Di (geminate voiced obstruent is more difficult that its corresponding singleton)

2. **place of articulation:**

The size of the cavity behind the oral constriction affects the aerodynamics of voicing. The larger cavity offers more compliant tissue, which allows the cavity to continue for a longer time to expand passively in response to airflow. A consequence of this is an asymmetry between voicing markedness in singleton bilabials as against alveolars and velars: [g] ≺ [d] ≺ [b].

This asymmetry holds among voiced geminates as well: [g:] ≺ [d:] ≺ [b:].

A Direct mapping from (a) onto (b) (c) (d)

from aerodynamics (a)
to markedness constraints (b and c)

a. Facts of phonetic difficulty
b. Speakers' implicit knowledge of the facts in (a)
c. Grammatical constraints induced from the knowledge in (b)
d. Sound patterns reflecting the activity of the constraints in (c)

Phonologically, these two difficulties are completely different, but phonetically, for example in both [g] (singleton, small cavity) and [b:] (geminate, large cavity) there is difficulty in maintaining voicing. Thus phonetics can posit a single scale of difficulty that includes both singletons and geminates:

*[+voice]: { g: ≺ d: ≺ b: ≺ g ≺ d ≺ b } (length ≺ place)

But the speakers can NOT encode the knowledge of these two phonetic difficulties in a single markedness constraint (b), thus the grammatical constraint induced from this knowledge can NOT be a single one.

A possible set of ranked Markedness constraints:

a. *[−son, +long, +dorsal, +voice] 'no voiced long dorsal obstruents' ≫
b. *[−son, +long, +coronal, +voice] 'no voiced long coronal obstruents' ≫
c. *[−son, +long, +labial, +voice] 'no voiced long labial obstruents' ≫
d. *[−son, –long, +dorsal, +voice] 'no voiced short dorsal obstruents' ≫
e. *[−son, –long, +coronal, +voice] 'no voiced short coronal obstruents' ≫
f. *[−son, –long, +labial, +voice] 'no voiced short labial obstruents'

A Direcṫ mapping from (a) onṫo (b) (c) (d)

a. Facts of phonetic difficulty
b. Speakers' implicit knowledge of the facts in (a)
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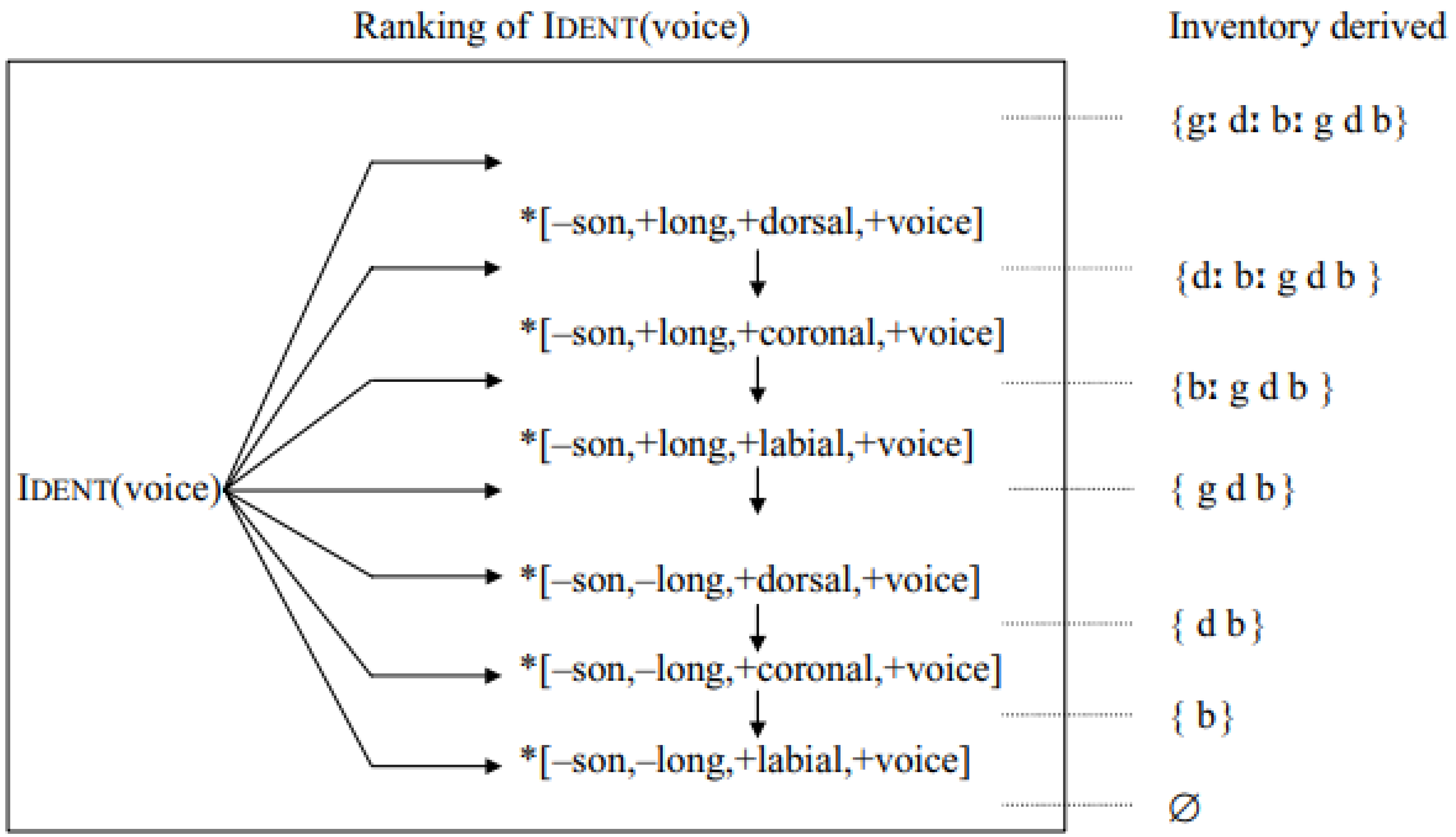
If these rankings are fixed, then the relative ranking of the Faithfulness constraint IDENT(voice) will determine the inventory of voiced obstruents.



A Direct mapping from (a) onto (b) (c) (d)

from scales (c) to sound patterns (d):

a. Facts of phonetic difficulty
b. Speakers' implicit knowledge of the facts in (a)
c. Grammatical constraints induced from the knowledge in (b)
d. Sound patterns reflecting the activity of the constraints in (c)

the activity of the discussed ranked Markedness constraints are confirmed by the data from real languages: (shaded cells = the voiced obstruent does not occur.

Place and length constraints on voicing contrasts

	b	d	g	bː	dː	gː
a. Delaware (Maddieson 1984)						
b. Dakota (Maddieson 1984)						
c. Khasi (Maddieson 1984)						
d. Various (citations under (1) above)						
e. Kadugli (Abdalla 1973), Sudan Nubian (derived environments; Bell 1971)				✶		
f. Cochin Malayalam (Nair 1979), Udaiyar Tamil (Williams & Jayapaul 1977), Sudan Nubian (root-internal only: Bell 1971)				✶	✶	
g. Fula (Maddieson 1984)						

Markedness scales and language-specific phonetics

In order to reflect closer asymmetries of production and perception, and achieve better descriptive coverage of the markedness of the voiced obstruents geminates we should state that any phonetic factor (not just length and place) that influences the difficulty of voicing can be reflected in the constraints and their ranking.

*[+voice]: $\{x \prec y\}$, where x, y is any pair of voiced segments, and the ratio of voiced closure to total closure duration is less in x than in y.

Such a scale is expected to explain the language-specific phonetic differences in the markedness of the voiced obstruents geminates.

Now, we evaluate the hypothesis that "knowledge of Markedness constraints stems from knowledge of the phonetic difficulty" by the scales of **perceptibility** and **effort.**

Scales of Perceptibility:

Certain featural distinctions are better perceived in some contexts than in others. For example, place distinctions are better perceived in velars than labials and coronals. As mentioned before, sometimes there are conflicts between Markedness constraints scales grounded in production vs those grounded in perception.

perceptuality of C-place: $\{ \text{coronal} \prec \text{labial} \prec \text{velar} \}$

This perceptibility scale is not aligned with the discussed articulatory scale for the voiced stops:

$\{ \text{velar} \prec \text{coronal} \prec \text{labial} \}$

Scales of Effort:

This scale generates a single constraint family, Lazy, whose members penalize articulations in proportion to the degree of effort they require. This makes it possible to compare disparate gestures in diverse contexts, and not just oral constrictions, like the number of jaw displacement gestures, the rate of displacement, etc. It can generate a precise system of predictions about the situations in which one articulation replaces another (e.g., consonant lenition).

Markedness Scales beyond Voicing

phonetics-free phonology

In a reply to Natural Phonology (Donegan and Stampe 1979) and phonetic determinism (Ohala 1979), Anderson writes: ‘The reason [to look for phonetic explanations] is to determine what facts the linguistic system proper is **not** responsible for: to isolate the core of features whose arbitrariness from other points of view makes them a secure basis for assessing properties of the language faculty itself’.

Syllables

Syllables look like good candidates for Anderson’s ‘arbitrary from other points of view', because the choice between different syllable structures seems to be central to phonology and unrelated to any extra-grammatical consideration: what perception, articulation, or processing factors could determine the choice between parses like [ab.ra] and [a.bra]?

Segment licensing

The fact that coda consonants are more likely to neutralize place and laryngeal contrasts is attributed to the idea that <u>codas license fewer features than onsets do</u>. Again, the segment licensing looks like a phonological constraint that is ‘arbitrary from other points of view’, nothing about perception, articulation, or processing leads us to expect any licensing asymmetry among syllable segments positions.

what we call ‘phonetic difficulty’ characterizes only the periphery of the human sound processing system, that is, the physical production of sound by the articulators and the initial levels of processing within the auditory system.

The deeper levels of the system, such as those that plan the execution of the utterance, or that access the lexicon in production or perception, are just as likely to yield understanding of how phonology works.

Speech Processing

The diachronic view of phonetics in phonology

Articulatory ease and perceptual recoverability might channel historical sound changes in certain directions, but they lack counterparts in the synchronic grammar.

First, phonetic factors determine a pattern of low-level variation. Then, language learners assign to the forms that they are mishearing a novel structural interpretation, differing from that assigned by the previous generation; at this point, phonological change has occurred.

CONCLUSION

Typological markedness factors sometimes do not match

ease of articulation
perceptuality
frequency
simplicity

A Review of Perceptual Cues and Cue Robustness

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Presented by
Elnaz and Felix

The goal of the chapter us to motivate phonotactic markedness from a perceptual perspective

Cue: Mean information in the acoustic signal that allows the listener to apprehend the existence of a phonological contrast.
The acoustic cues vary with context (articulators that are continuous and overlapping).

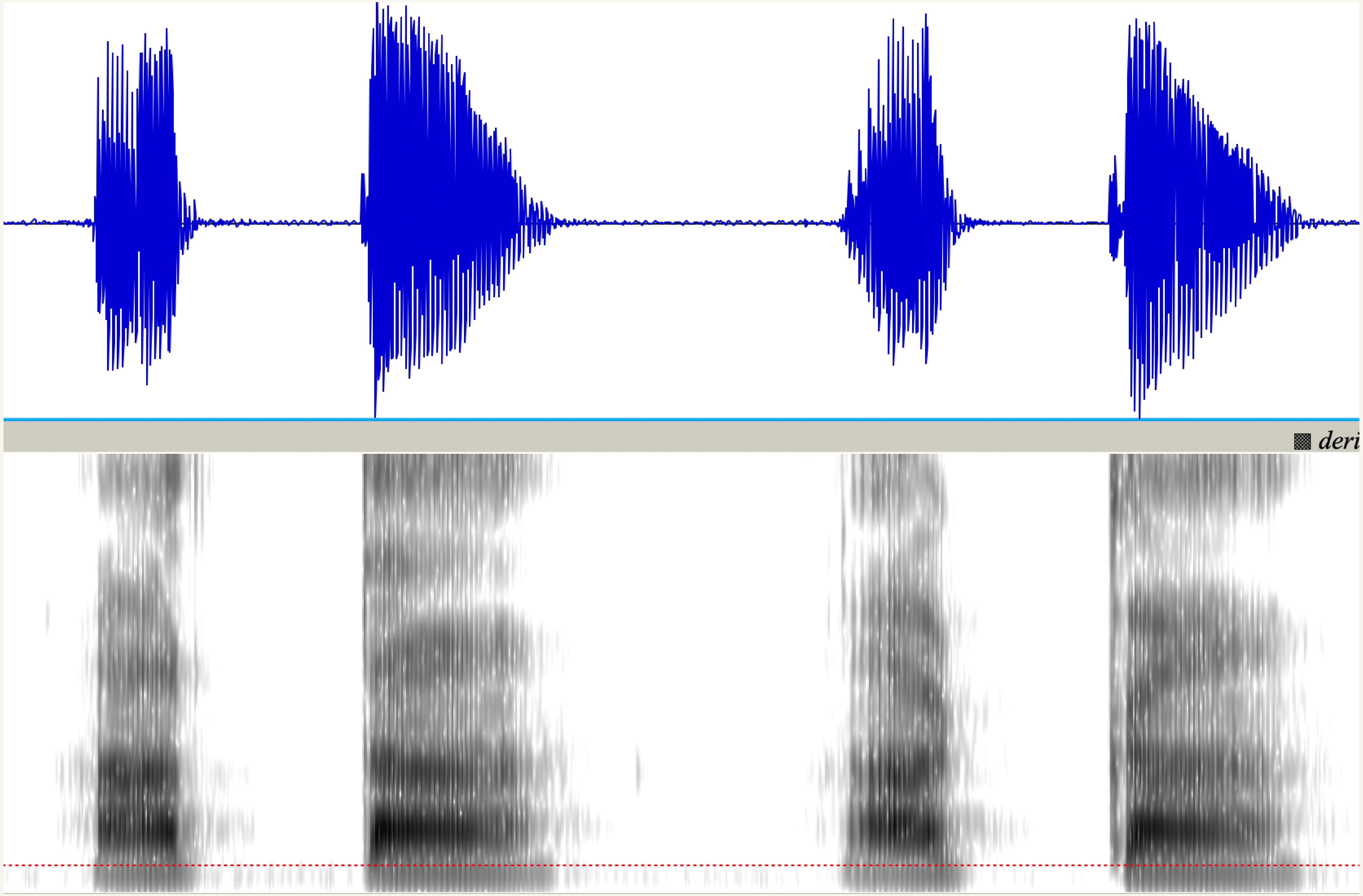
2. Survey of auditory cues

2.1. Cues to place contrast in consonants

2.1.1 Formant transitions:

When a consonant constriction is superimposed on an adjacent vowel, the deformation of the vocal tract results in localised perturbations of the vowel's formant structure as the vocal tract changes shape.
Both the second and third formant (F2 and F3) transtitions provide the listener with cues to the place of articulation of consonants.

[apa] vs [aka]



2.1.2 Fricative noise:

Frication noise is aperiodic with a relatively long duration. Its spectrum is shaped primarily by the cavity in front of the noise source.
As fricatives have continuous noise that is shaped by the cavity in front of the constriction, they can convey information about adjacent consonants in a fashion that is similar to vowel.

For some fricatives, mostly sibilants, the spectrum is sufficient to allow listeners to distinguish the place of articulation, whereas for some other with lower amplitude (e.g. [v], [θ]), the F2 is necessary.

2.1.3 Stop Release Bursts

-The complete occlusion results in a build-up of pressure behind the closure. The release of this pressure results in brief high amplitude noise.

[p] vs [t] vs [k]

-The transitions dominate place perception (F2).

2.1.4 Nasal cues

Nasals have an oral constriction that results in formant transitions in the adjacent vowels.
The nasal pole-zero pattern serves as a place cue.

In addition, listeners identify the place of articulation more reliably from formant transitions than the nasal portion of the signal.

2.2. Cues to manner contrast in consonants

- An abrupt attenuation of the signal in all frequencies is a cue to the presence of a **stop**.
- A complete attenuation of the harmonic signal but with fricative noise provides the listener with cues to the presence of a **fricative**.
- A less severe drop in amplitude accompanied by a nasal murmur are cues to **nasal** manner.
- **Glides** impose rapid in spectral changes during the formant transitions by the relative gradualness of the transitions into and out of the peak.

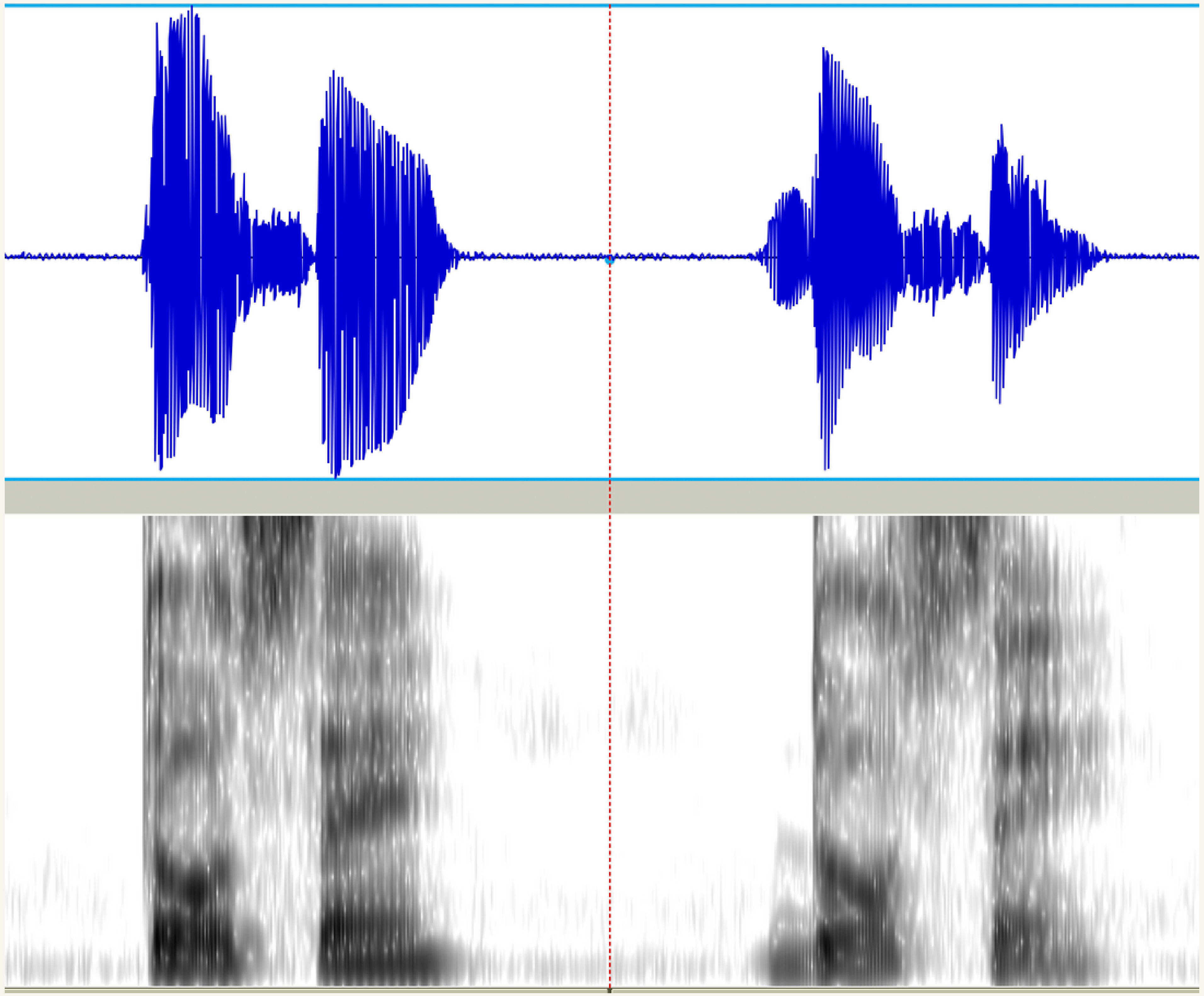
- Manner cues tend to be more robust in masking noise than place cues.

2.3 Cues to voicing contrast in consonants

Periodicity in the signal is an obvious cue. However:

- In fricatives, the presence or absence of periodicity during the frication noise is a strong cue to voicing.
- For stops in syllable initial, the primary cue appears to be VOT.

Spanish [dose] 'twelve' vs [tose] 'he coughes'



2.4 Cues to vowel quality

-Vowels are made with a relative open vocal tract and the main cues are found in the resonances of the vocal tract.

- Vowel distinctions are generally thought to be based on the relative spacing of the fundamental frequency (F0) and the first three vocal resonances (F1, F2 and F3)

F1 = height
F2 = Backness
F3 = roundness

3. Cue robustness as a principle of segmental organization

Normally, it is rare for speech to occur in the absence of some environmental background. This means that a robustly encoded phonological contrast is more likely to survive signal degradation or interference in reception.

3.1 Auditory influences on cue robustness

How the auditory system can change a particular portion of the speech signal has to be taken into account. Not all acoustic features that can be discerned in a spectogram or waveform will necessarily have an equal impact on the listener.

There is a marked burst of activity of the auditory nerve fibres in response to the onset of a stimulus signal.

Perceptual cue robustness

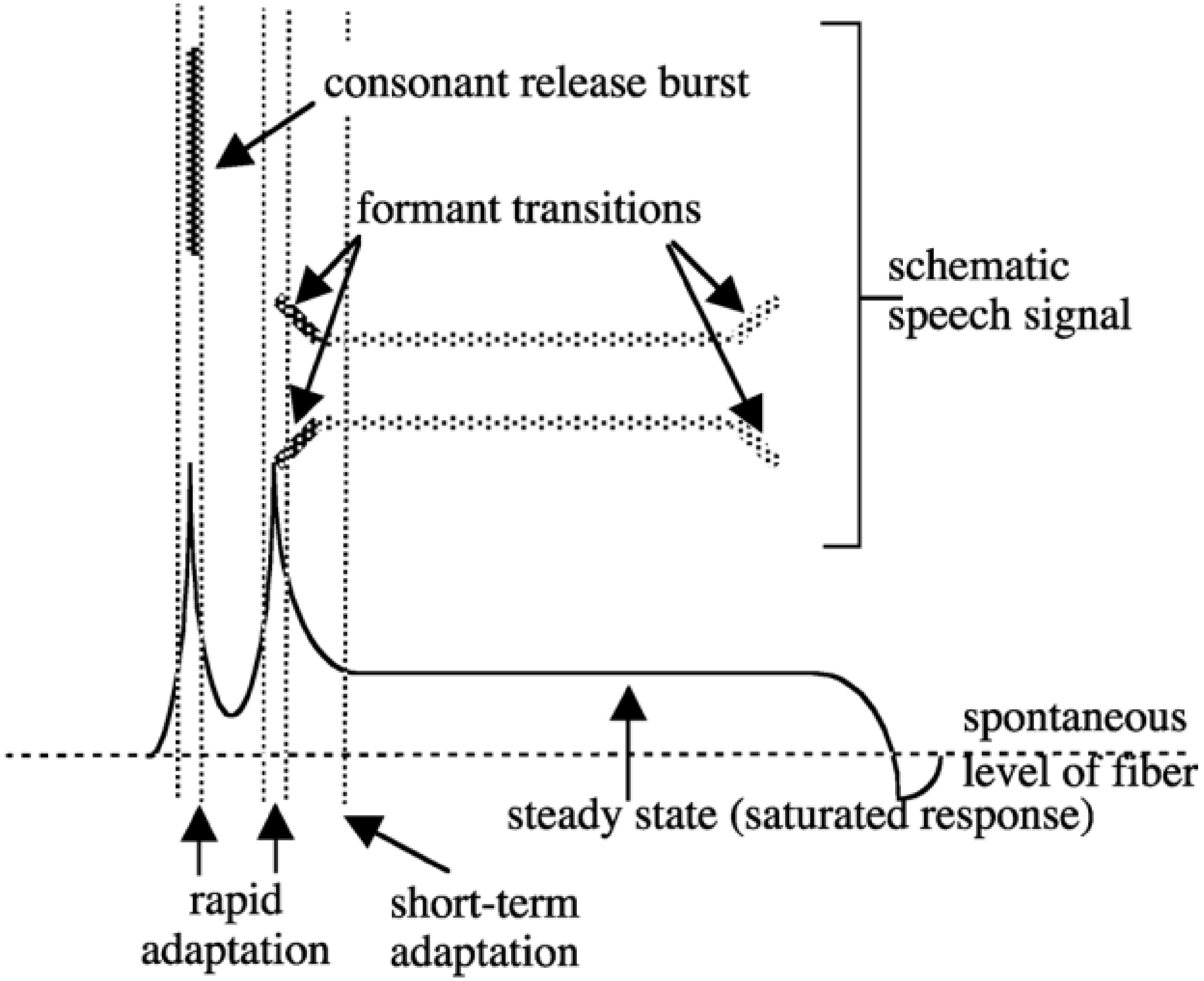


Figure 2.4 Schematic illustration of the onset-offset response asymmetry in the sequence [dat˺] showing rapid and short-term adaptation. The portions of the signal that benefit from the boost in auditory nerve response are darkened, while portions that are rendered less salient appear more faintly (after Wright 2001)

3.1.2 Robustness in noise

Two main factors determine the auditory response: frequency and periodicity!
Cues that are found in aperiodic noise, such as the place cues in the noise of fricatives, affricates, and consonant release bursts, are highly vulnerable. The intensity of the noise and the sharpness of the onset will determine the degree to which the information is lost due to masking.

- Sibilant fricatives are the most resistant to masking, because they are more intense than non-sibilant fricatives.
- Onset release bursts are more resistant to masking than the non-sibilant fricatives: the release is preceded by both of which lead to an increase in activity in the auditory response.
- Place cues in the formant transitions are more resistant to loss through masking because they are periodic.
- Place and manner cues in the nasal pole and zero are resistant to masking; however, they tend to be weaker place cues than the actual formant transitions.

3.2 Overlap, redundancy, and parallel transmission

Mattingly's proposal: A driving force for the organization of speech is the need for both a maximal speed of signal transmission and a robust encoding in the information in the signal. This is based on the tendency for articulators to overlap in the production of speech.
Information about one articulation may show overlap with information about another.

Whether or not overlap results in an increase or a decrease in the number of cues depends on the characteristics of adjacent segments.

E.g. two stops, very little increase in information, and a loss of a release burst). On the other hand, the overlap between consonants and vowels both speeds up the transmission of the signal and encodes the information in the signal redundantly.

However, Mattingly points out that complete overlap may result in a loss of cues; if a gesture is co-extensive with another gersture with a higher degree of stricture, the gesture with a lesser degree of stricture may have no impct on the acoustic signal because it will be fully obscured.

e.g. [pla] in which a complete overlap between the /p/ closure and the /l/ constriction could lead to a loss of information about /l/

3.3 Modulation and speech salience

Kawasaki and Ohala's proposal: Change (modulation) along an acoustic dimension, such as frequency or amplitude, will result in increased salience of the cues in the portion of the signal where the change occurs. Therefore, the greater the modulation and the more dimensions that are involved, the greater salience.

The benefits of modulation can be seen in alternating CV sequencing that is typical of most languages. The alternating closures and apertures create a large modulation along amplitude dimension, and smaller abrupt changes in frequency in the formant transitions into and out of the closures.
As the articulators move from the consonant constriction towards the vowel target, the greater the distance the formants travel, the greater the increase in salience.

The sequences that result in a greater degree of signal modulation are the same ones that result in increased cue redundancy.

e.g. The alternation of consonants and vowel (CV) results in a robust encoding in information both because it results in the greatest perceptual benefit from overlap, and because it creates an optimal signal modulation.

Sequences with a similar degree of aperture (**e.g.** stop + stop) result in poor encoding both because they result in very little perceptual benefit from overlap, and also because they result in very little signal modulation.

The modulation principle alone does not take into account the benefit of cue redundancy in determining the relative perceptual benefit of a particular sequence.

In [pla], information is robustly encoded because /p/, with complete closure, procedes the /l/ with partial closure, which, in turn, precedes /a/ with even greater degree of aperture.

Information about the liquid is not lost as a result of overlap (as might be the case if it were to proceed the stop), since a portion of it overlaps with the following vowel, and it creates a signal in which information about any one segment is distributed reduntantly throughout the signal.

4. Preferred segmental sequences

(CVCV): at each transition from vowel to consonant there are numerous cues to both the vowel's quality and to the consonant's place, manner, and voicing.

C+G+V+G+C is slightly worse. How bad/good depends on how similar the glide transitions are to the vowel formants and the formant transitions of the consonant. Glides are dynamic; the greater the similarity between the glide and the consonant, the more easily the glide will be lost.

The sonority sequencing principle has proven a particular useful tool in phonology for describing many of the patterns that result from perceptual factors such as these as well as articulatory factors

CV, CVC
CGV, CGVC,
CLV, CLVC,
sCV

In past formulations of the Sonority Constraint, there was not principled way of accounting for [s]; they were labeled as 'special' or 'exceptional'.

In one that is based on perceptual robustness, a stranded consonant is dispreferred unless it has sufficiently robust internal cues to survive in the absence of formant transitions.
The only consonants that have reliable cues at their peaks of stricture are sibilant fricatives. This is arguably the reason why syllables of the type sCV are cross-linguistically common, even though they have a sonority reversal.

Conclusions

-Organising the consonants and vowels of speech in certain patterns is going to produce a signal that will encode enough information for the listener to recover place, manner, and voicing more reliably than other patterns will.
-The more cues point to a contrast and the less susceptible to masking or loss those cues are the most likely the contrast is to survive.
-The ideal segmental organization will be those that are most commonly attested cross-linguistically: CV, CGV, and so on. These patterns allow maximum degree of overlap between segments and the least risk to portions of the signal that contain vulnerable cues such as consonant bursts or weak frication.
-The best codas will be glides and liquids, nasals that do not constrast for place, stops that do not contrast for place, and fricatives and affricates with high intensity energy.