

Lecture 7: Prosodic Phonology

Dafydd Gibbon

Guangzhou Prosody Lectures
Jinan University, Guangzhou, Guangdong
November 2017

Overview

Topics to be covered:

- Prosodic phonology as prosodic knowledge
- Methods of prosodic phonology
- Phonological approaches:
 - Finite state phonologies
 - Event phonologies
 - Hierarchical phonologies

Prosodic Knowledge

behavioural knowledge
intellectual knowledge

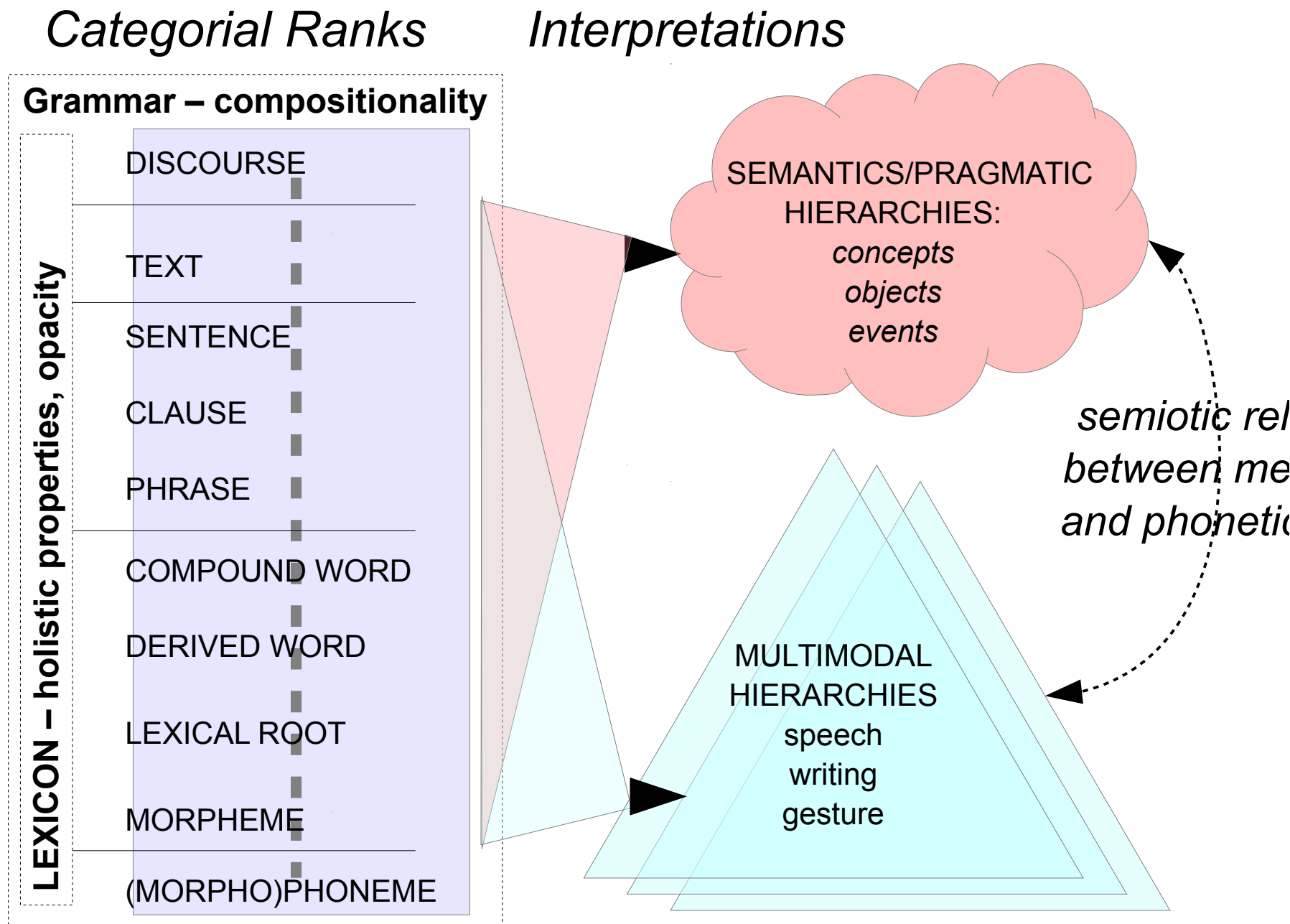
Prosodic Knowledge

behavioural knowledge
intellectual knowledge

The context:

Multilinear Grammar as Linguistic Knowledge

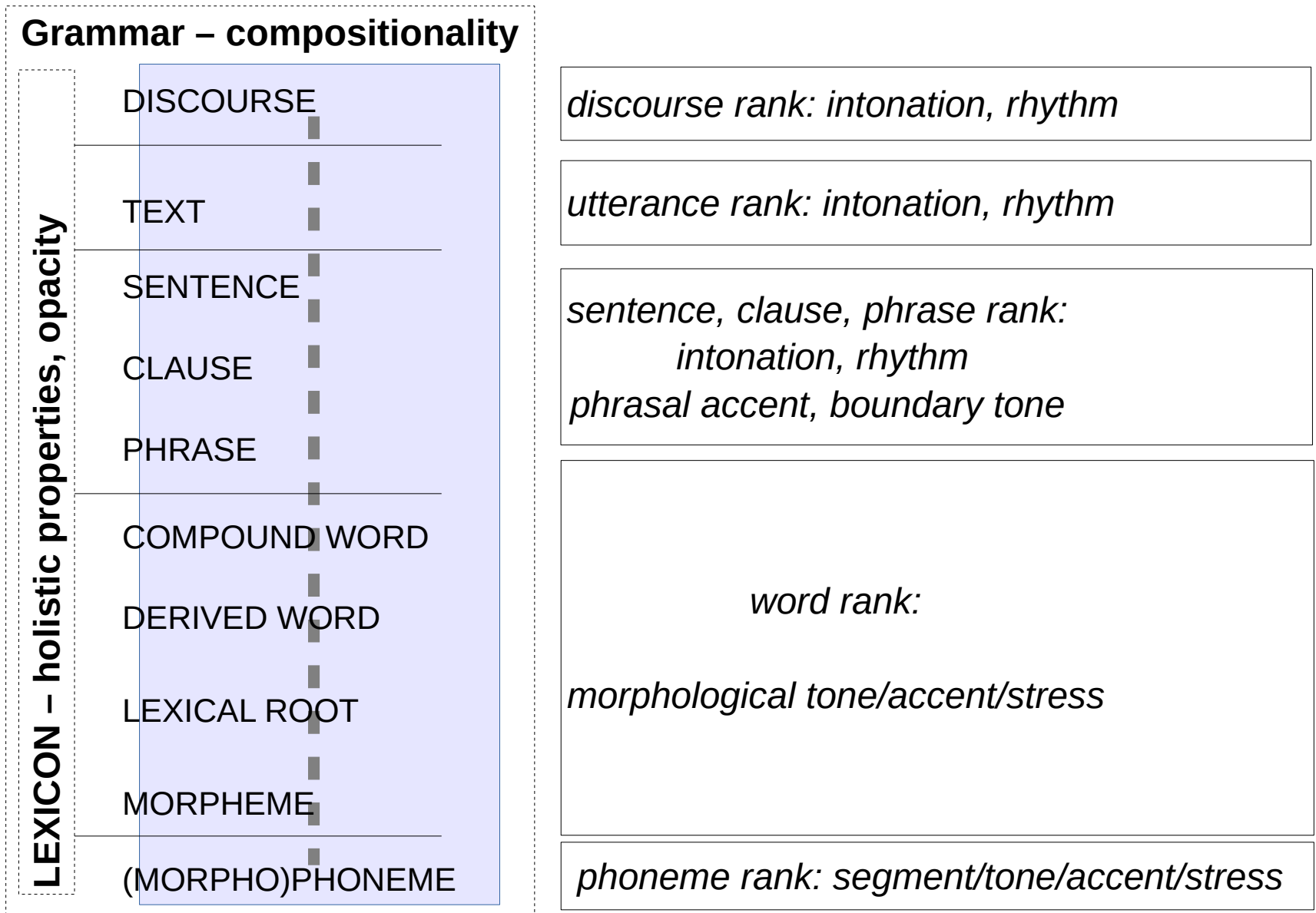
The architecture of language: Ranks and Interpretations



Prosody in the Ranks and Interpretations Model

Rank

Prosodic-phonetic Interpretation



Prosodic Knowledge

Knowledge is neither objective nor permanent

Why? Because ...

Knowledge is a multidimensional function of

observational method

selected domain

representation

Prosodic Knowledge

Knowledge is neither objective nor permanent

Why? Because ...

Knowledge is a multidimensional function of

observational method

selected domain

representation

Everyday knowledge and scientific knowledge differ along these three dimensions

Prosodic Knowledge

Knowledge is neither objective nor permanent

Why? Because ...

Knowledge is a multidimensional function of

observational method

selected domain

representation

Everyday knowledge and scientific knowledge differ along these three dimensions

and in both fields people change properties of these dimensions, motivated by many different kinds of interest

Prosodic Knowledge

- Knowledge as multidimensional activity:
 - Empirical method:
 - observation, experiment, intuition, ...
 - Empirical domain, partly a function of the method:
 - modality:
 - speech, writing, gesture; multimodal
 - rank in the architecture of language:
 - phonetic, phonological, lexical, grammatical, textual, discoursal, ...
 - dynamics of language:
 - 4 temporal domains: utterance, acquisition, history, evolution
 - processing of speech, writing, gesture
 - Representation:
 - informal text
 - formal model
 - predictive theory

Prosodic Knowledge

- Knowledge as multidimensional activity:
 - Empirical method:
 - observation, experiment, intuition, ...
 - Empirical domain, partly a function of the method:
 - modality:
 - speech, writing, gesture; multimodal
 - rank in the architecture of language:
 - phonetic, phonological, lexical, grammatical, textual, discoursal, ...
 - dynamics of language:
 - 4 temporal domains: utterance, acquisition, history, evolution
 - processing of speech, writing, gesture
 - Representation:
 - informal text
 - formal model
 - predictive theory

What is the difference ...

- between each of the following
 - everyday practical knowledge of speech
 - phonetic knowledge
 - phonological knowledge?

Prosodic Phonology and Prosodic Phonetics

Methods, Domains, Representations

Prosodic Phonology and Prosodic Phonetics

- Empirical methods of prosodic analysis:
 - Direct observation
 - systematic qualitative analysis
 - quantitative analysis
 - Measurement
 - measuring instruments
 - models
 - visualisation and statistical analysis

... and not only of prosodic analysis

Prosodic Phonology and Prosodic Phonetics

- Prosodic domains and their methods:
 - Neurophonetics:
 - medical instrumental measurement methods
 - Articulatory phonetics, speech production:
 - direct observational methods
 - instrumental measurement methods
 - simulation with formal models (articulatory speech synthesis)
 - Acoustic phonetics, speech transmission:
 - signal processing instrumental measurement methods
 - simulation with formal models (speech synthesis)
 - Auditory phonetics:
 - medical instrumental measurement methods to
 - behavioural perception tests
 - surveys
 - reaction tests

Prosodic Phonology and Prosodic Phonetics

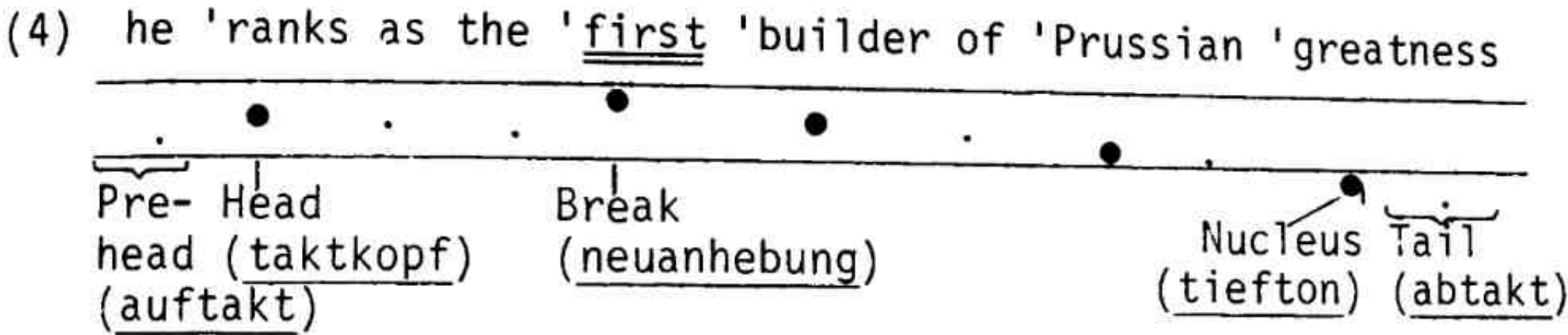
- Representations:
 - Articulatory phonetics, speech production:
 - phonetic transcriptions and annotations
 - pedagogical transcriptions and visualisations
 - phonetic transformations and visualisations
 - categories and structures with articulatory features
 - Acoustic phonetics, speech transmission:
 - signal processing instrumental measurement methods
 - simulation with formal models (speech synthesis)
 - Auditory phonetics
 - categorial perception of units of speech
 - categorisation of auditory features: high, low, bright, dark, ...

Prosodic Phonology and Prosodic Phonetics
Pedagogical and other practical notations

Older textbook approaches: 'iconic' transcription

- Intonation vocabulary items represented iconically in graphic transcriptions:
 - dots or dashes for 'stressed' syllables
 - smaller dots for 'unstressed' syllables
- Intonation Group represented iconically:
 - sequence of vocabulary items
 - declination as sloping sequence
 - reset or 'break' to re-start Intonation Group
 - final 'nuclear' stress/accent/tone

Graphical 'iconic' transcription



Top: Klinghardt & Klemm (1920)
 Bottom: Armstrong & Ward (1926)

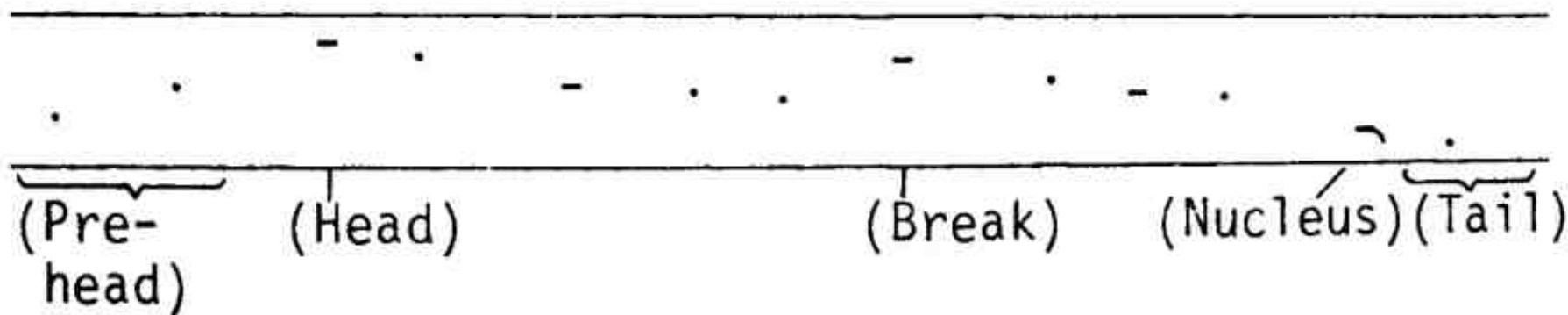
IG → NonFinal* Final

NonFinal → Bk Ana* Accent (Str)* Unstr

Final → Ana* Nucleus Unstr*

Graphical 'iconic' transcription

(5) it was ˈten oʻˈclock on a †cold Deˈcember ˈmorning



Top: Klinghardt & Klemm (1920)
Bottom: Armstrong & Ward (1926)

IG → NonFinal* Final

NonFinal → Bk Ana* Accent (Str)* Unstr

Final → Ana* Nucleus Unstr*

Graphical 'iconic' transcription

(4) he 'ranks as the 'first' builder of 'Prussian 'greatness

Pre-head (taktkopf) (auftakt) Head (taktkopf) Break (neuanhebung) Nucleus (tiefton) Tail (abtakt)

(5) it was 'ten o'clock on a †cold De'cember 'morning

(Pre-head) (Head) (Break) (Nucleus) (Tail)

Top: Klinghardt & Klemm (1920)
 Bottom: Armstrong & Ward (1926)

IG → NonFinal* Final
 NonFinal → Bk Ana* Accent (Str)* Unstr
 Final → Ana* Nuc Unstr*

Pedagogical notations

- Contour Tone Notations (e.g. English)
 - ‘tadpole notation’
 - height of accent on perceived pitch scale:



- represents 3 types of information:
 - 1) pitch height
 - 2) pitch direction
 - 3) point of attachment to a lexically or phrasally stressed syllable
- Advantage: intuitively comprehensible
- Disadvantage: phonetically vague, inaccurate

Pedagogical and practical notations

- Pitch level notations (e.g. English)
 - ToBI, ‘Tone and Breaks’, notation
 - named height of accent on perceived pitch scale:

H* **L*** **L*H** **LH*** **H*L** **HL*** **H*H**

(in some older approaches, numbers are used to represent pitch heights)

- represents 3 types of information:
 - 1) pitch height
 - 2) pitch direction
 - 3) point of attachment to a lexically or phrasally stressed syllable
- Advantage: intuitively comprehensible
- Disadvantage: phonetically vague, inaccurate

Pedagogical and practical notations

- Pitch level notations (e.g. English)
 - ToBI, ‘Tone and Breaks’, notation
 - named height of accent on perceived pitch scale:

H* **L*** **L*H** **LH*** **H*L** **HL*** **H*H**

modified from Pike, Trager & Smith: pitch heights and junctures

- represents 3 types of information:
 - 1) pitch height
 - 2) pitch direction
 - 3) point of attachment to a lexically or phrasally stressed syllable
- Advantage: intuitively comprehensible
- Disadvantage: phonetically vague, inaccurate

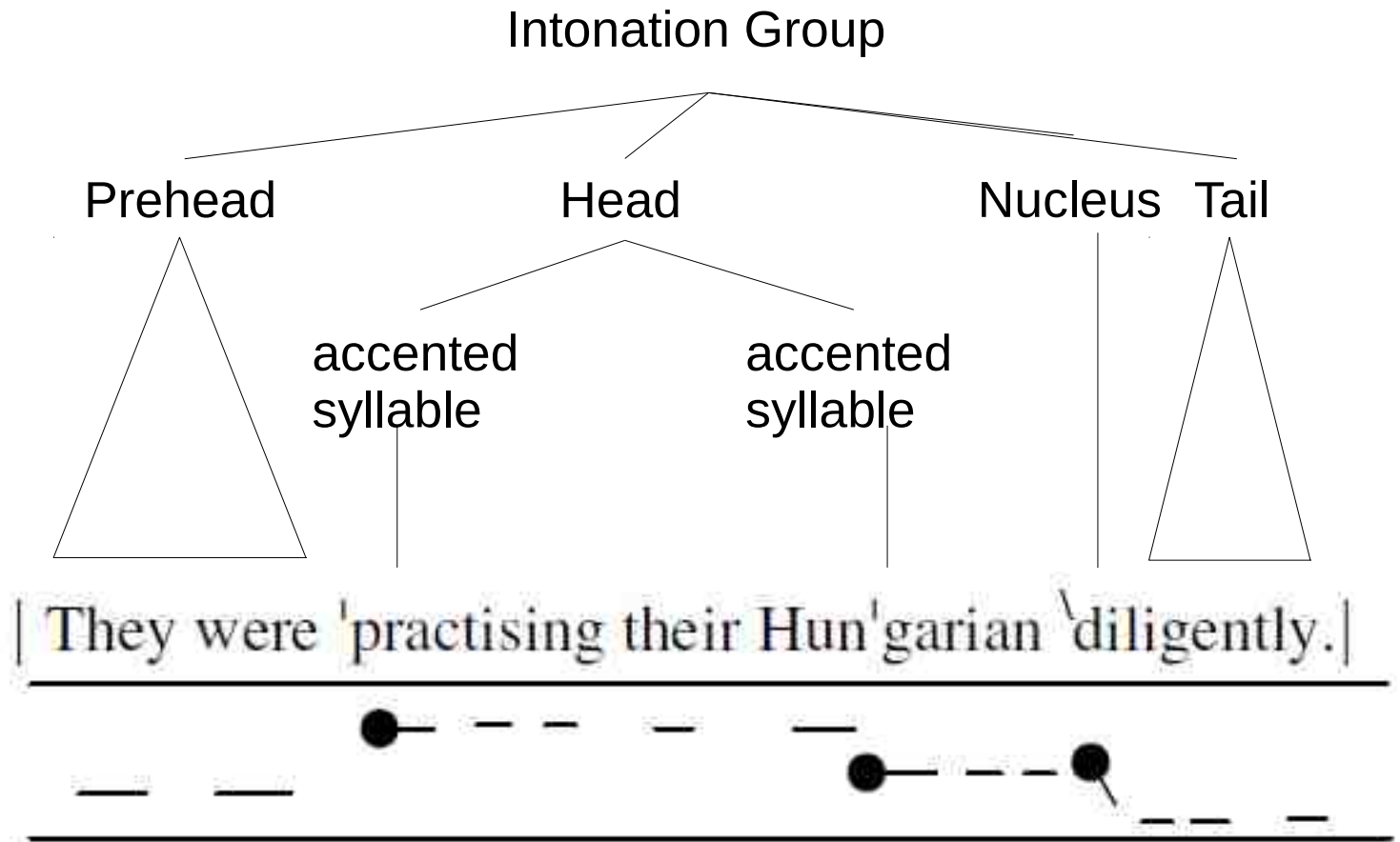
Early phonological representations

- Tonic stress marks and tone group structure
 - here: O'Connor & Arnold 1961

pedagogical description as early prosodic phonology

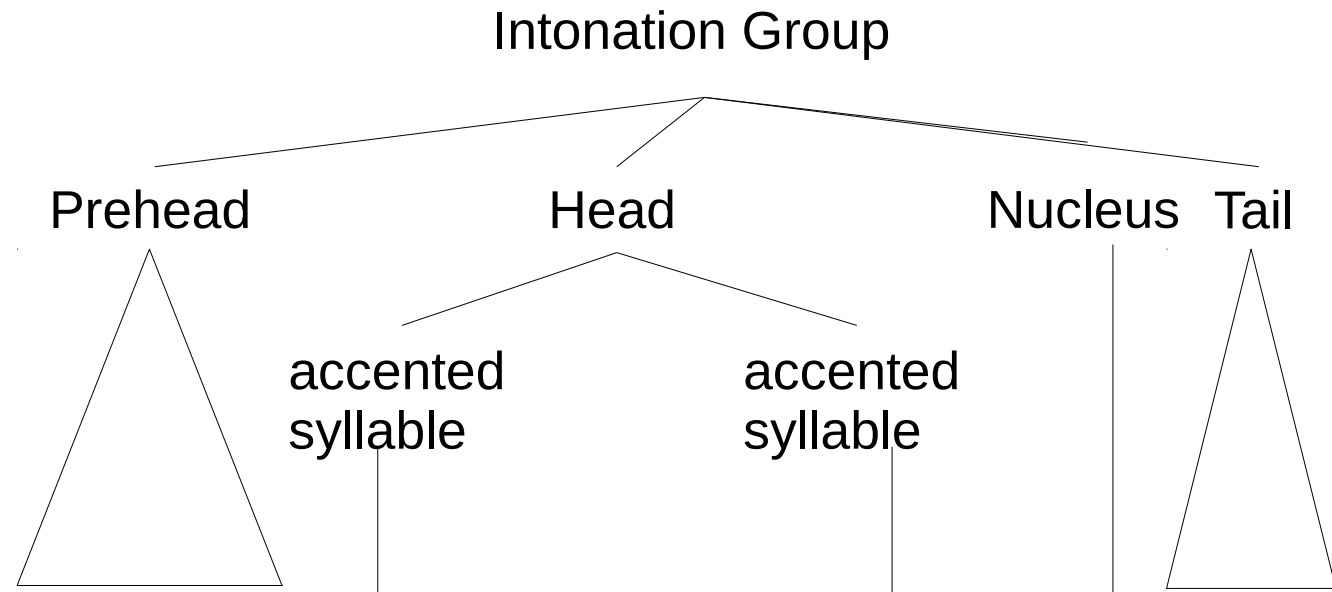
tonetic stress marks

tadpole notation



Early phonological representations

- Tonic stress marks and tone group structure
 - here: O'Connor & Arnold 1961



With this kind of approach it is already possible to generalise the description into an intonation grammar:

IG → (Prehead) (Head) Nucleus (Tail)

Head → Accented syllable

(every other syllable in the Head is unaccented)

Early phonological representations

- Jassem's Rhythm Units

- Rhythm Unit Sequence (RUS)
- Total Rhythm Unit (TRU)
- Anacrusis (ANA)
- Narrow Rhythm Unit (NRU)
- Unstressed/Stress Syllable (USyll, SSyll)

A grammar for Jassem's Rhythm Theory:

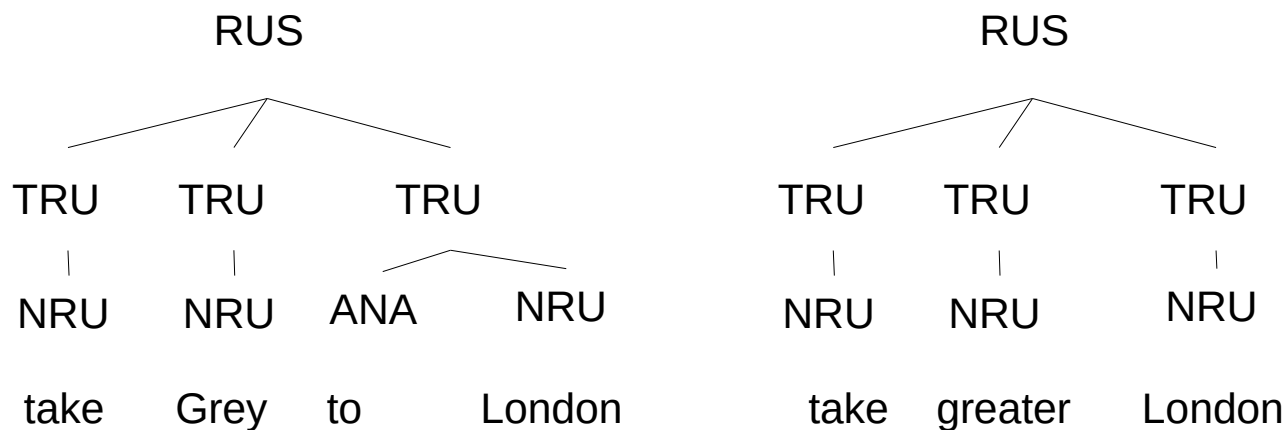
RUS → TRU TRU*

TRU → (ANA) NRU

ANA → USyll USyll*

NRU → SSyll USyll*

- Disambiguation:

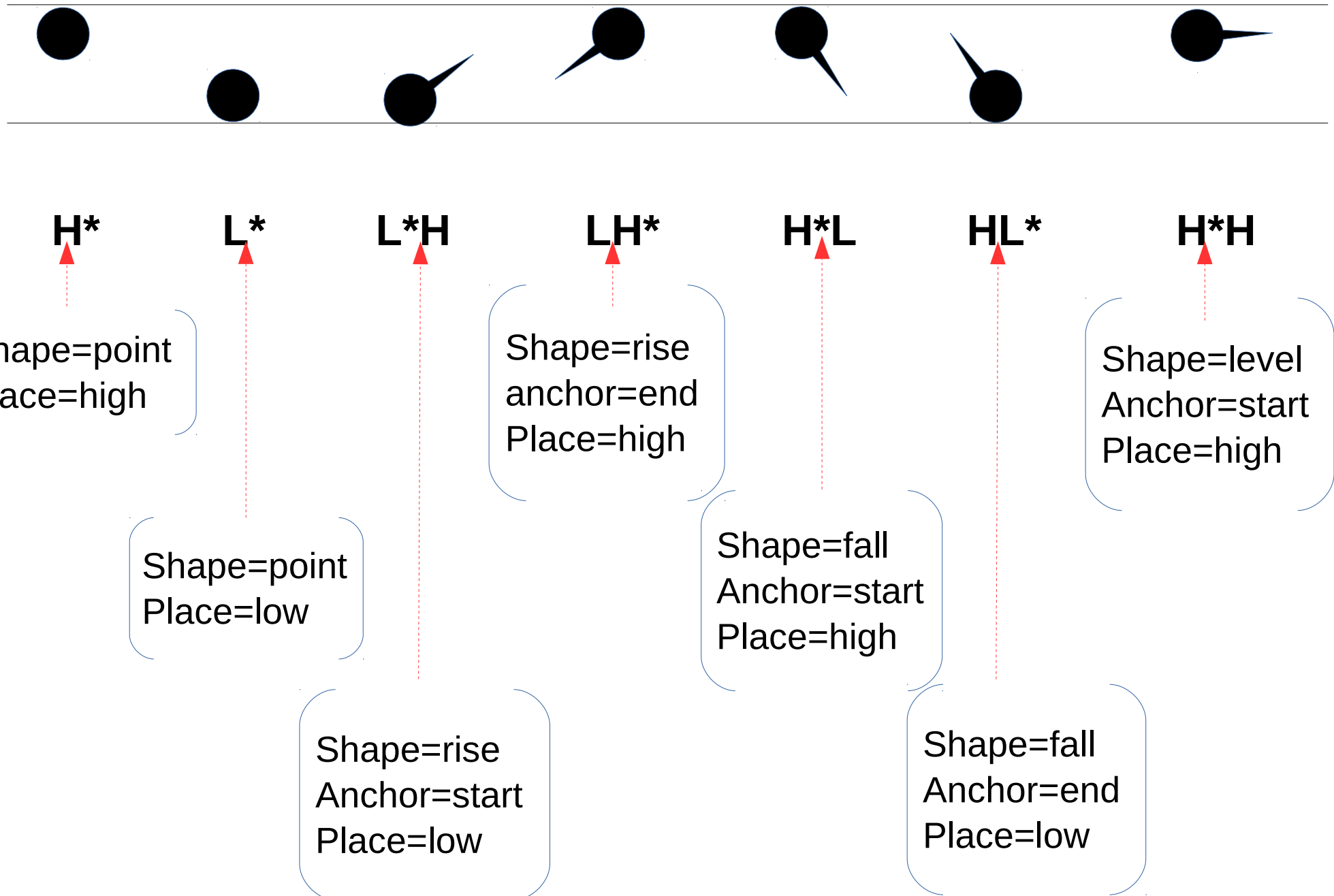


Discuss:

summer dresses
some addresses

he bought her chocolates

From pedagogical to scientific notations



The syntax (= structure) of prosody

- Compositional operations in prosody:
 - Sequences:
 - concatenation of tokens (cf. standard phonologies & grammars)
 - Parallel sequences:
 - synchronisation; overlap (cf. autosegmental phonology)
 - Groups:
 - generalisation; domain (cf. metrical phonology)
- Prosodic grammars:
 - Event logic, interval calculus:
 - Steven Bird: Event phonology
 - Julie Carson-Berndsen: Time-Map phonology
 - Finite State Grammars:
 - e.g. Janet Pierrehumbert

Three key parameters

- Phrasing (boundary placement)
 - ‘tonality’
- Accentuation (stress/accent placement)
 - ‘tonicity’
- Shape (sequence of levels/contours)
 - ‘tone’:
 - global intonation contour
 - shape of pitch accents and boundary tones

Removing some terminological confusion!

- The assignment of prominence to words is confusingly referred to by different scholars as

Stress – Accent – Focus – Tone

- I clarify as follows:
 - **Stress** is a lexical or grammatical position in a word, phrase, sentence, text (cf. ‘Nuclear Stress’)
 - **Accent** is a phonetic interpretation of a stress position as a pitch-intensity-duration pattern
 - **Focus** is the information-relevant semantic interpretation of an accent at a stress position
- Finally:
 - **Tone** is reserved for contrastive lexical and morphosyntactic functions of fundamental frequency.

Inductive analysis: from pitch patterns to categories

Phonetic mode (signal analysis):

- Domains:
 - time functions (articulatory, acoustic, auditory)
- Analysis:
 - time domain
 - frequency domain (spectrum)

Tonal tokenisation (e.g. ToBI):

BoundaryTone PitchAccentTone PitchAccentTone* BoundaryTone

Boundary tone: { H%, %L% }

PitchAccentTone: { H*, L*, L*H, LH*, H*L, HL*, H*H }

Contour parsing (Tonetics):

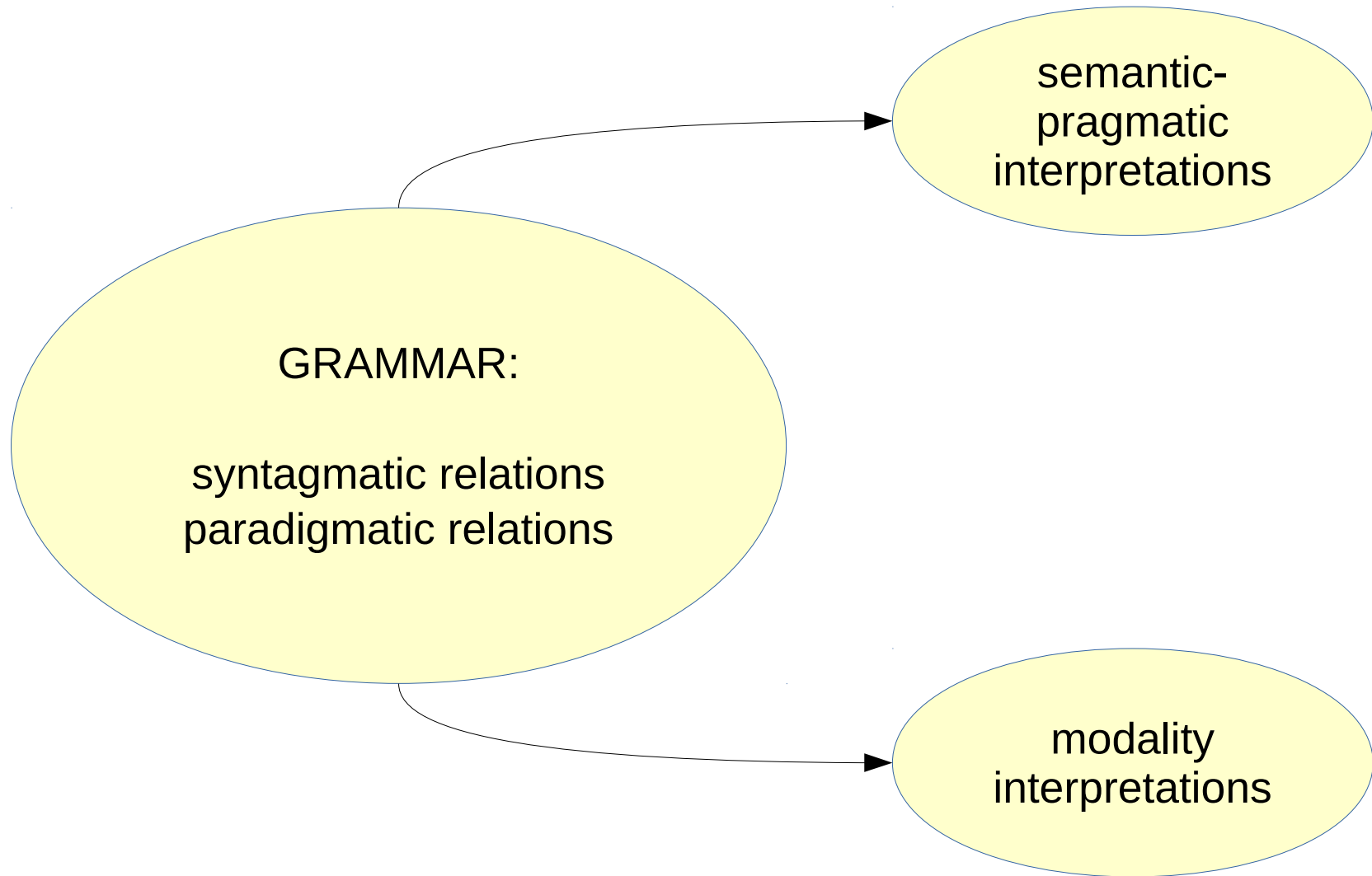
prehead head body nucleus tail

Categorial interpretation (prosodic phonologies):

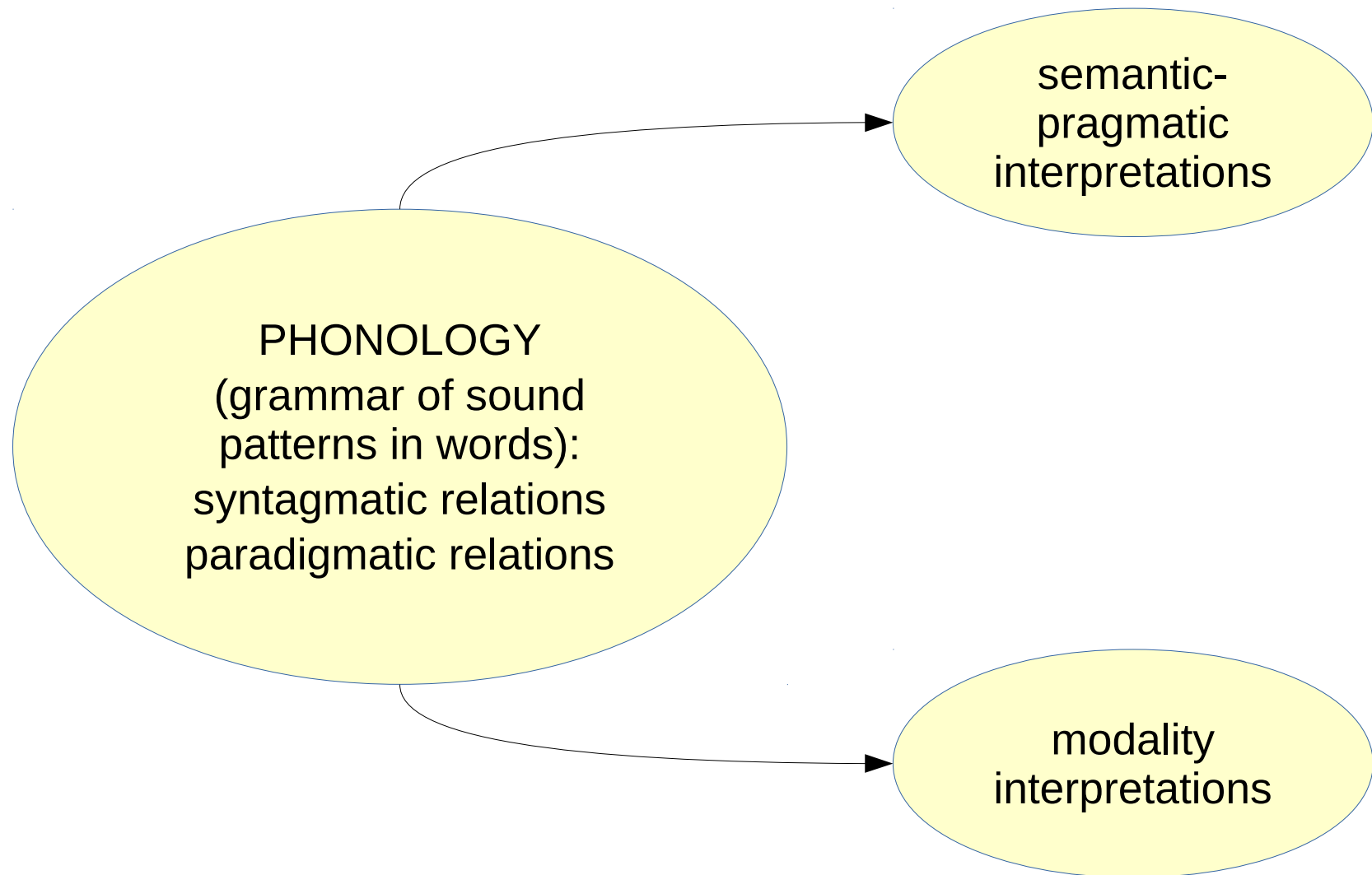
- Configurative: Initial/final boundary; ip, IP boundary
- Contrastive: accents
- Culminative: accent placement

Prosodic Phonology as the Grammar of Prosody

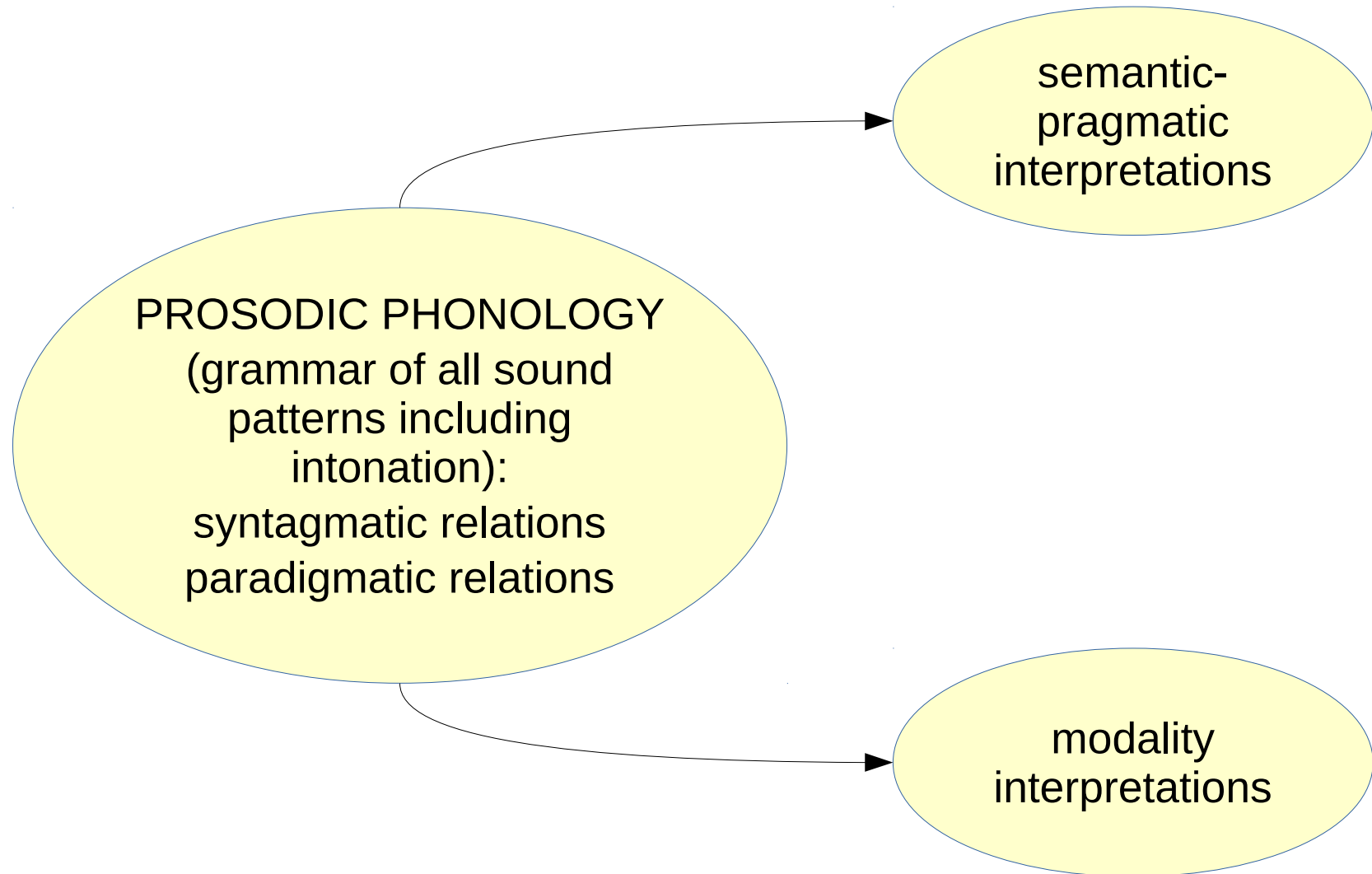
Basic principles



Basic principles



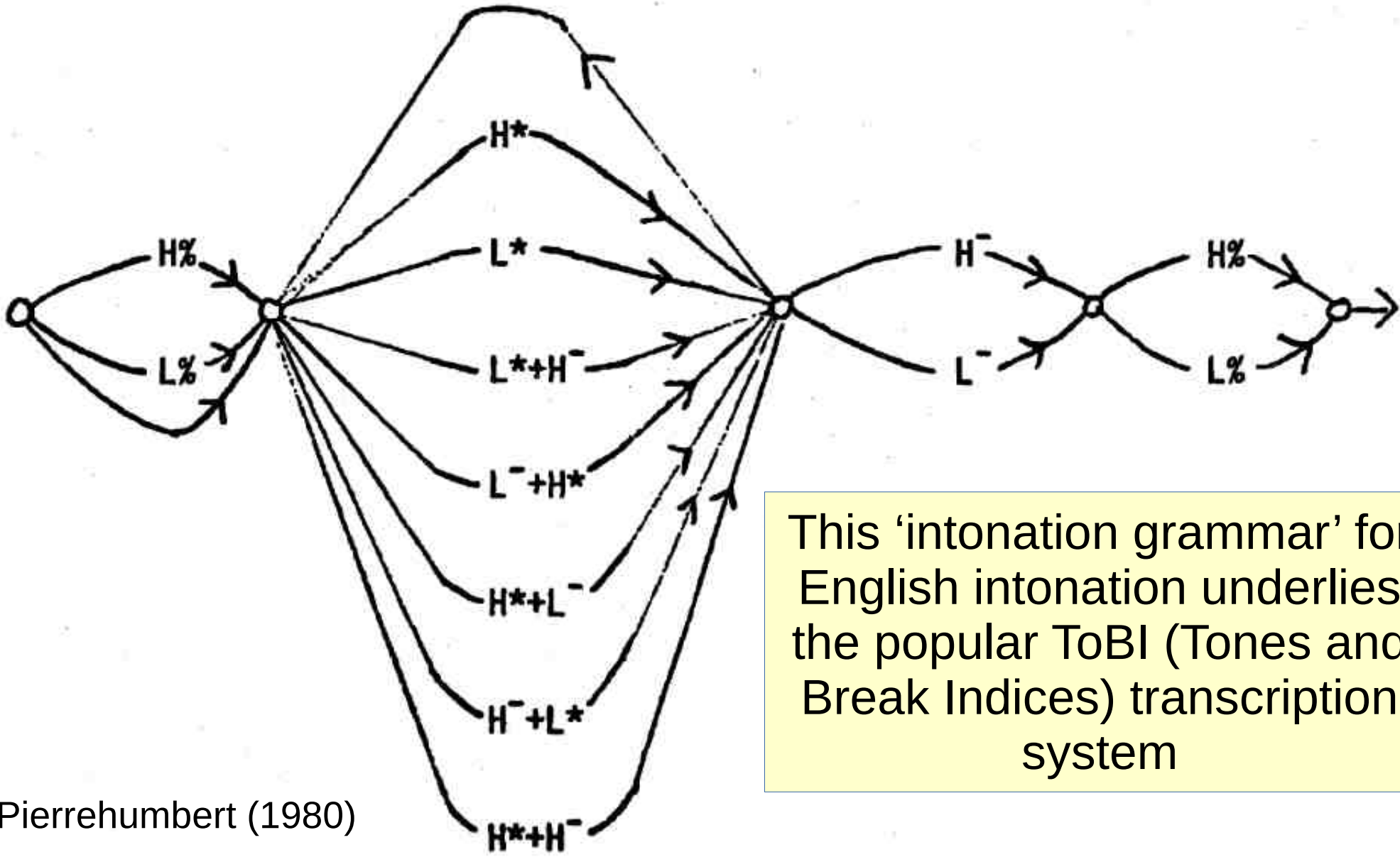
Basic principles



Grammar of English intonation:
Finite State models of syntagmatic relations

Syntagmatic structure: a Finite Machine Model

14) Boundary Tone Pitch Accents Phrase Accent Boundary Tone

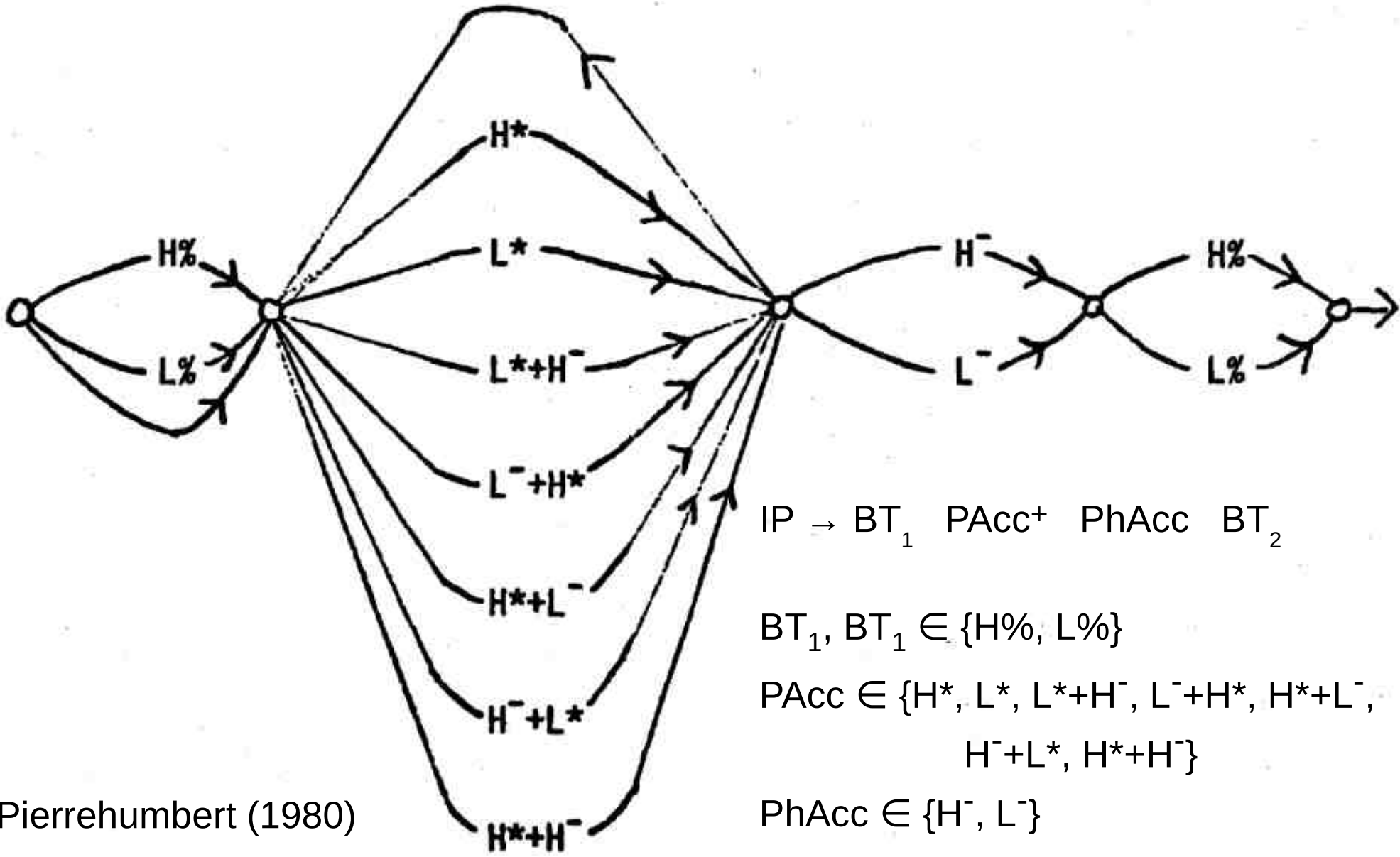


This 'intonation grammar' for English intonation underlies the popular ToBI (Tones and Break Indices) transcription system

Pierrehumbert (1980)

Syntagmatic structure: a Finite Machine Model

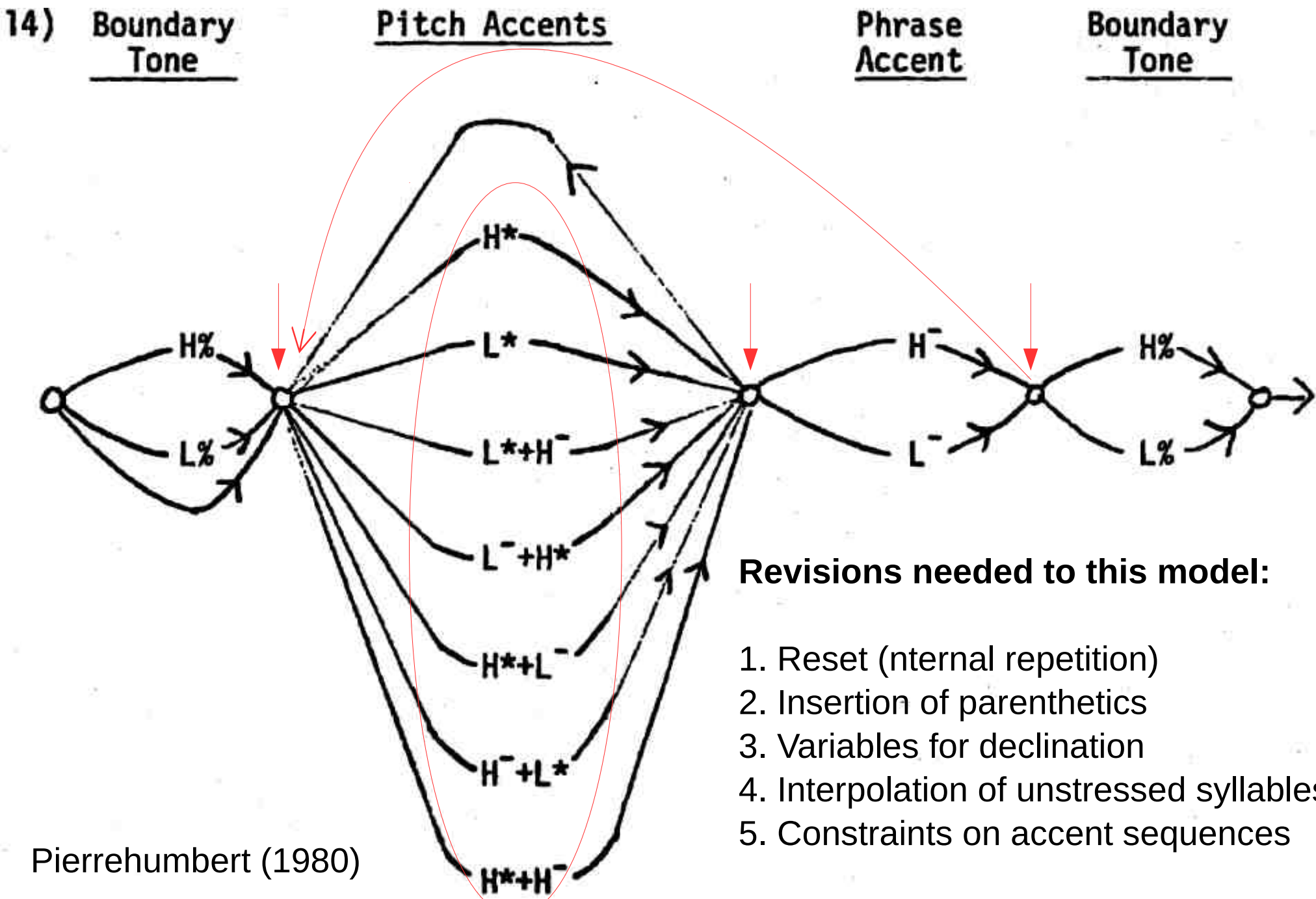
14) Boundary Tone Pitch Accents Phrase Accent Boundary Tone



$IP \rightarrow BT_1 \text{ PAcc}^+ \text{ PhAcc } BT_2$
 $BT_1, BT_2 \in \{H\%, L\%\}$
 $PAcc \in \{H^*, L^*, L^*+H^-, L^-+H^*, H^*+L^-, H^-+L^*, H^*+H^-\}$
 $PhAcc \in \{H^-, L^-\}$

Pierrehumbert (1980)

Syntagmatic structure: a Finite Machine Model



Revisions needed to this model:

1. Reset (nternal repetition)
2. Insertion of parenthetics
3. Variables for declination
4. Interpolation of unstressed syllables
5. Constraints on accent sequences

Pierrehumbert (1980)

Prosodic grammar – tone sandhi

Downstep, upstep in Niger-Congo tone systems

Tem (ISO 639-3 *kth*) as a clear case example:

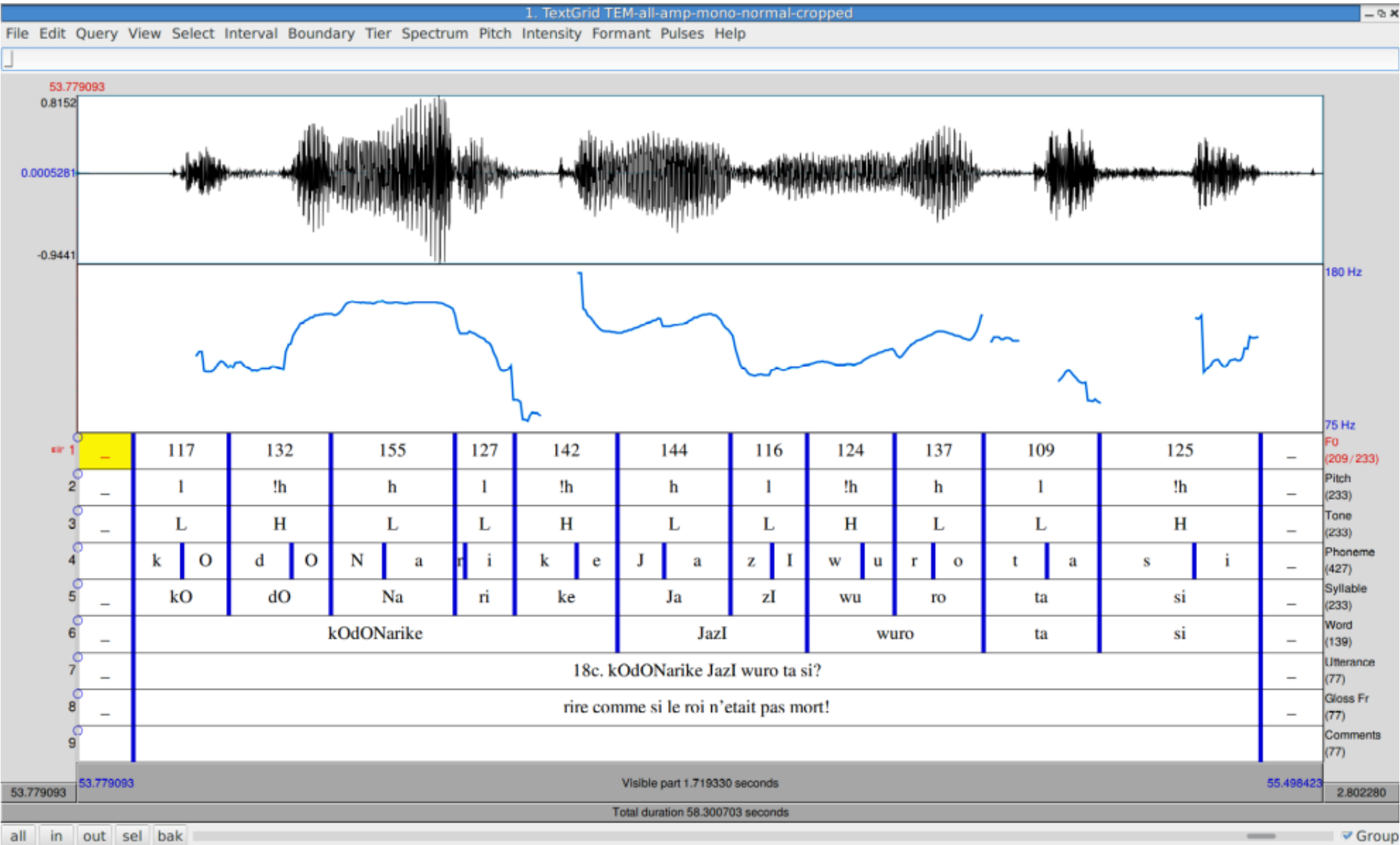
- Phonetic interpretation of Tem tone sequences:
 - inventory of 2 tones, H and L
 - L H: partial automatic downstep producing terracing
 - H L: complete automatic upstep
 - L semiterrace sequences: quasi-constant low
 - Initial H, L: extra high, extra low, respectively
 - Notation:
 - Underlying *tone categories*: upper case (H, L)
 - Surface *phonetic pitch categories*: lower case (h, !h, l, ^l)

Thus, in a traditional notation:

H → !h / L ___ (terrace restart by automatic partial downstep)

L → ^l / H ___ (semiterrace extension by automatic total upstep)

Downstep, upstep in Niger-Congo tone systems



TEM kodoNa

Downstep, upstep in Niger-Congo tone systems

Generalisations over tone sequences:

Many possible formal tools:

- notations, symbolisms, formalisms (Carnap)
- alphabets (categories, features)

Visualisations are an aid to productivity and insight:

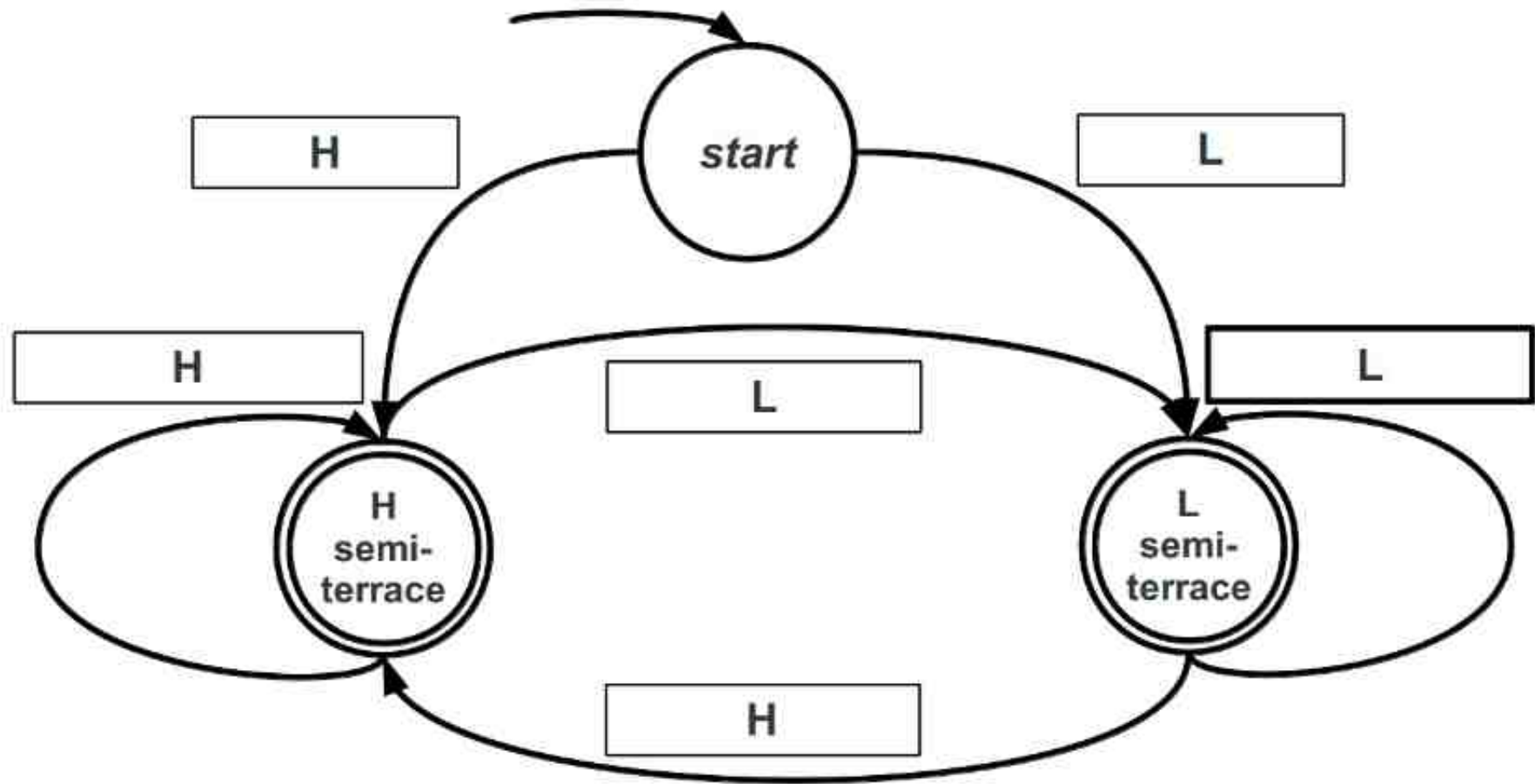
- *parse trees, metrical grids, autosegmental lattices, constraint tableaux ...*

But it is desirable to visualise

not only *data representations* for tonal sequences and associations, as listed above

but also *underlying grammars for tonal sequences and associations* ?

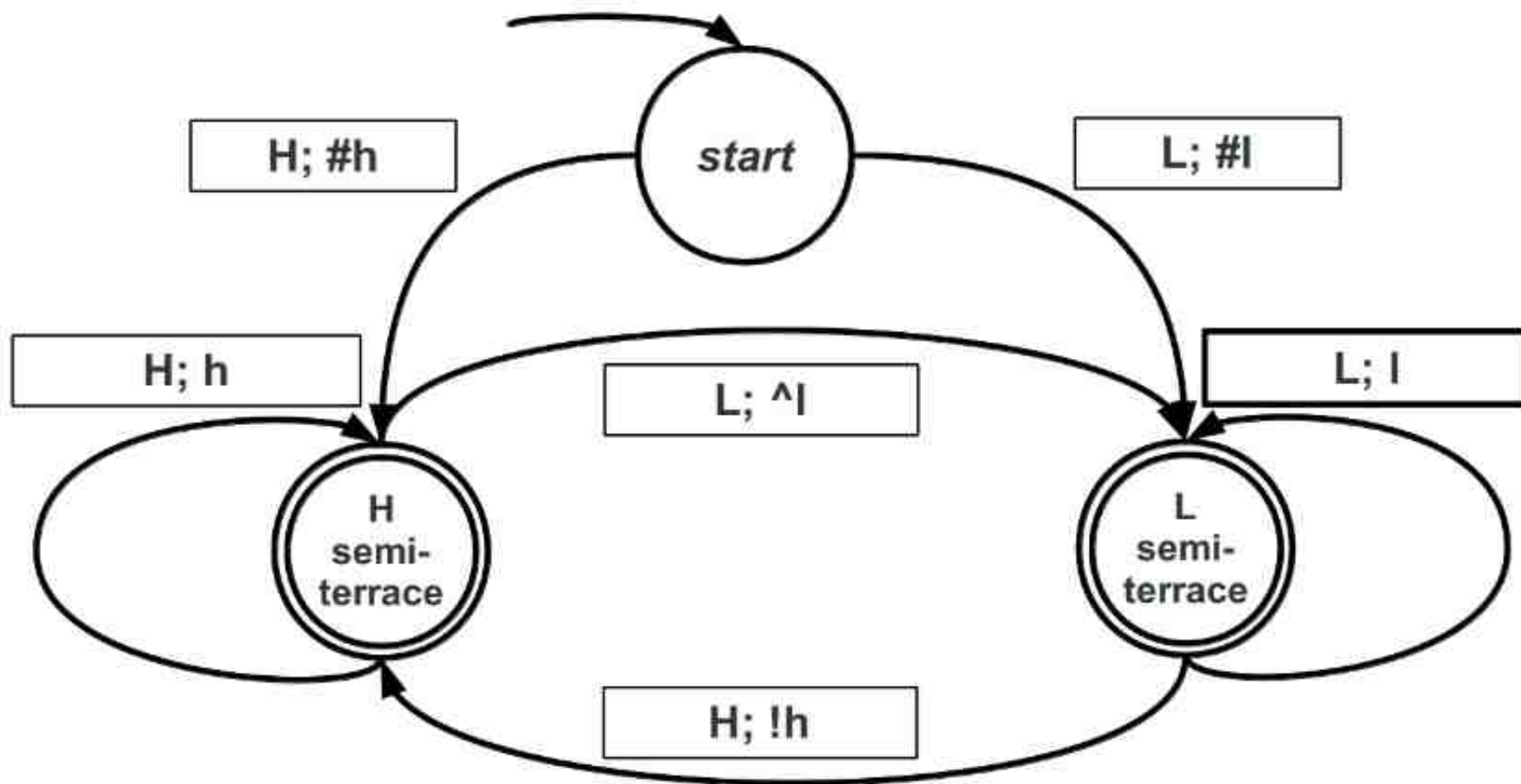
Downstep, upstep in Niger-Congo tone systems



Relevant contexts for tones
start and end
H and L terrace cycles
HL and LH terrace transitions

The graph defines 6 contexts (edges) for tone-allotone (tone-pitch) relations.

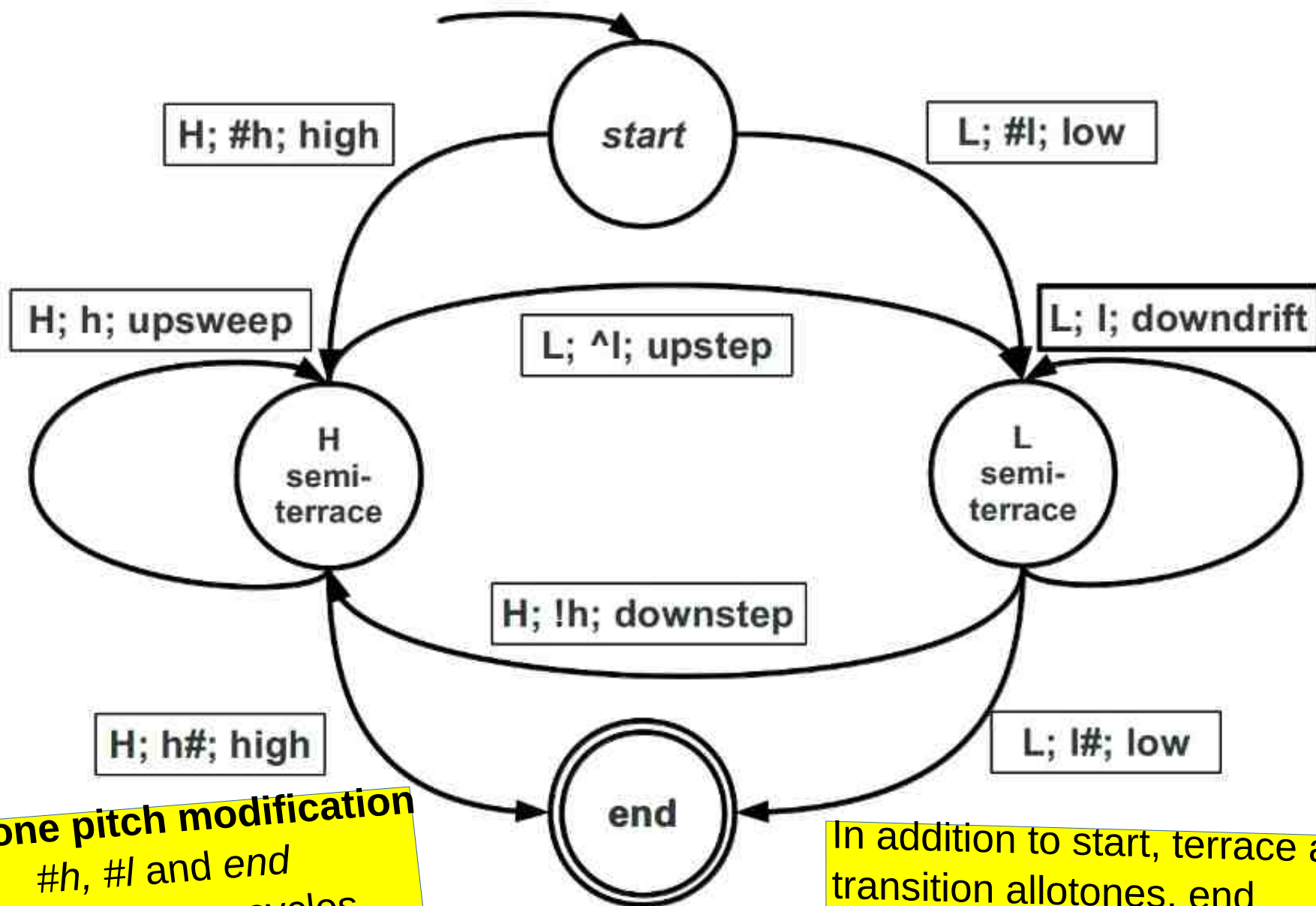
Downstep, upstep in Niger-Congo tone systems



Allotone pitch modification
#h, #l and end
h and l terrace cycles
^| and !h terrace transitions

In addition to start, terrace and transition allotones, end allotones also need to be made explicit.

Downstep, upstep in Niger-Congo tone systems



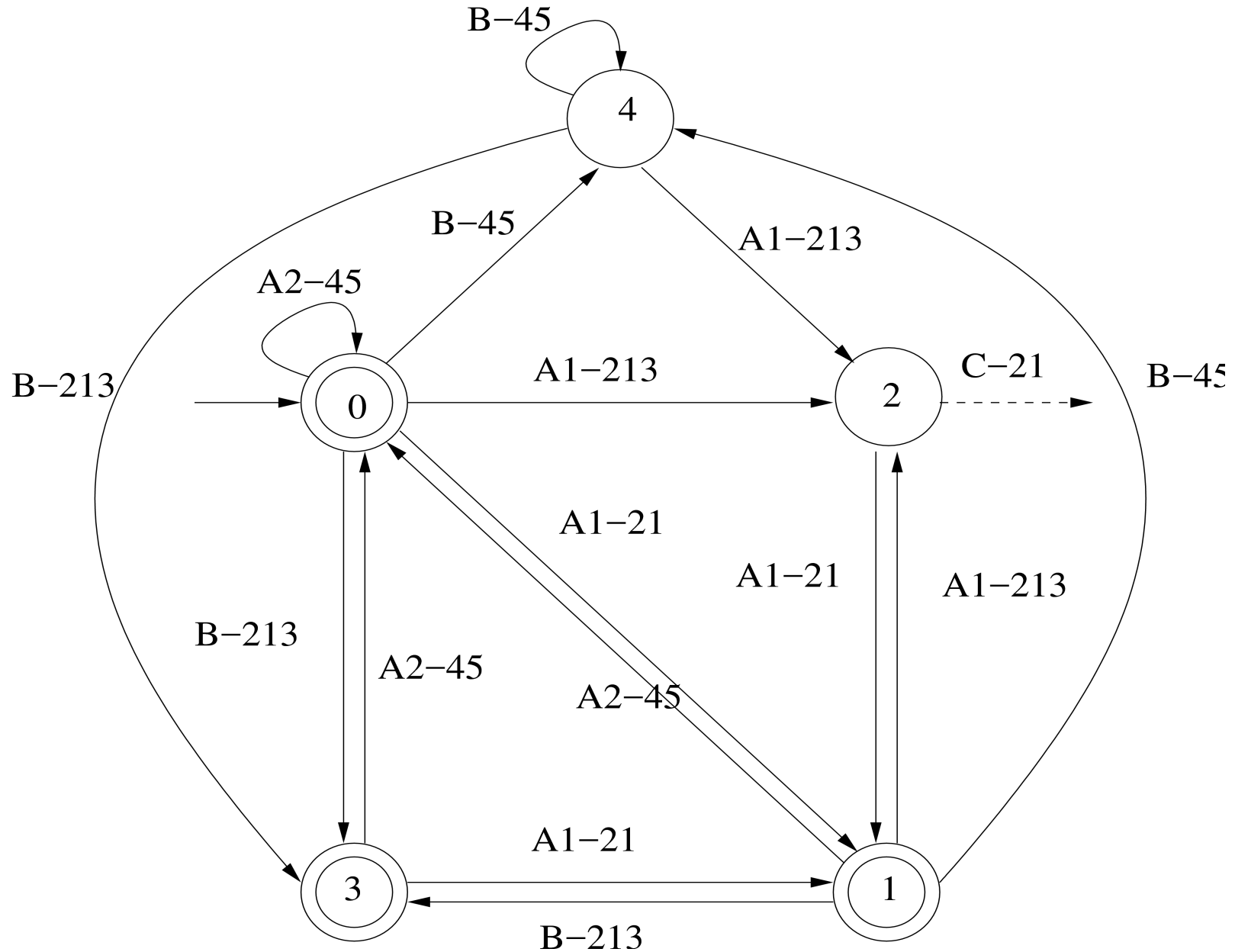
Allotone pitch modification
 #h, #l and end
 h and l terrace cycles
 ^l and !h terrace transitions

In addition to start, terrace and transition allotones, end allotones also need to be made explicit.

Sino-Tibetan tone

- Tianjin Mandarin

Tone sandhi in Chinese tonal systems: Tianjin Mandarin



Jansche, M. 1998. A Two-level Take on Tianjin Tone. In: I. Kruij-Korabayova, ed. *Proceedings of the Third ESSLLI Student Session*. Chapter 12.

**Sequential and simultaneous syntagmatic relations:
the role of time in the grammar of prosody**

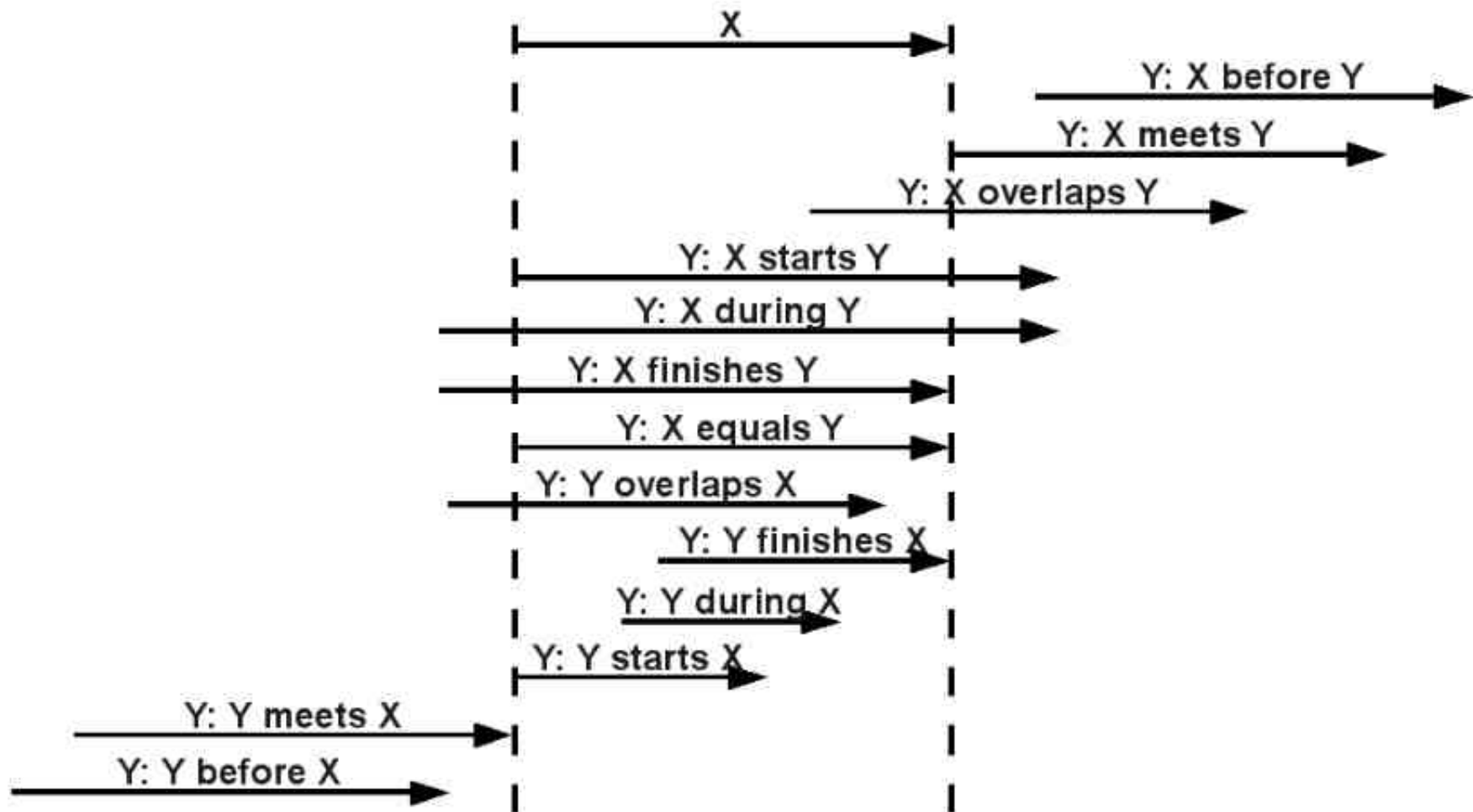
Timing: Basic Characteristics

- Timing:
 - either a property of an event
which is a relation between a state and an interval:
event = <state, interval>
 - e.g.
 - the state and the interval of speaking an utterance
 - the state and the interval of producing a vowel
 - or one of 13 possible relations
between two (or more) intervals / events
 - which are in sequence
 - which overlap

The Allen Interval Calculus

- Timing:

13 possible relations between the intervals of all kinds of events:



The Allen Interval Calculus

- Timing:

13 possible relations between the intervals of all kinds of events:

Examples of timing

Dialogue

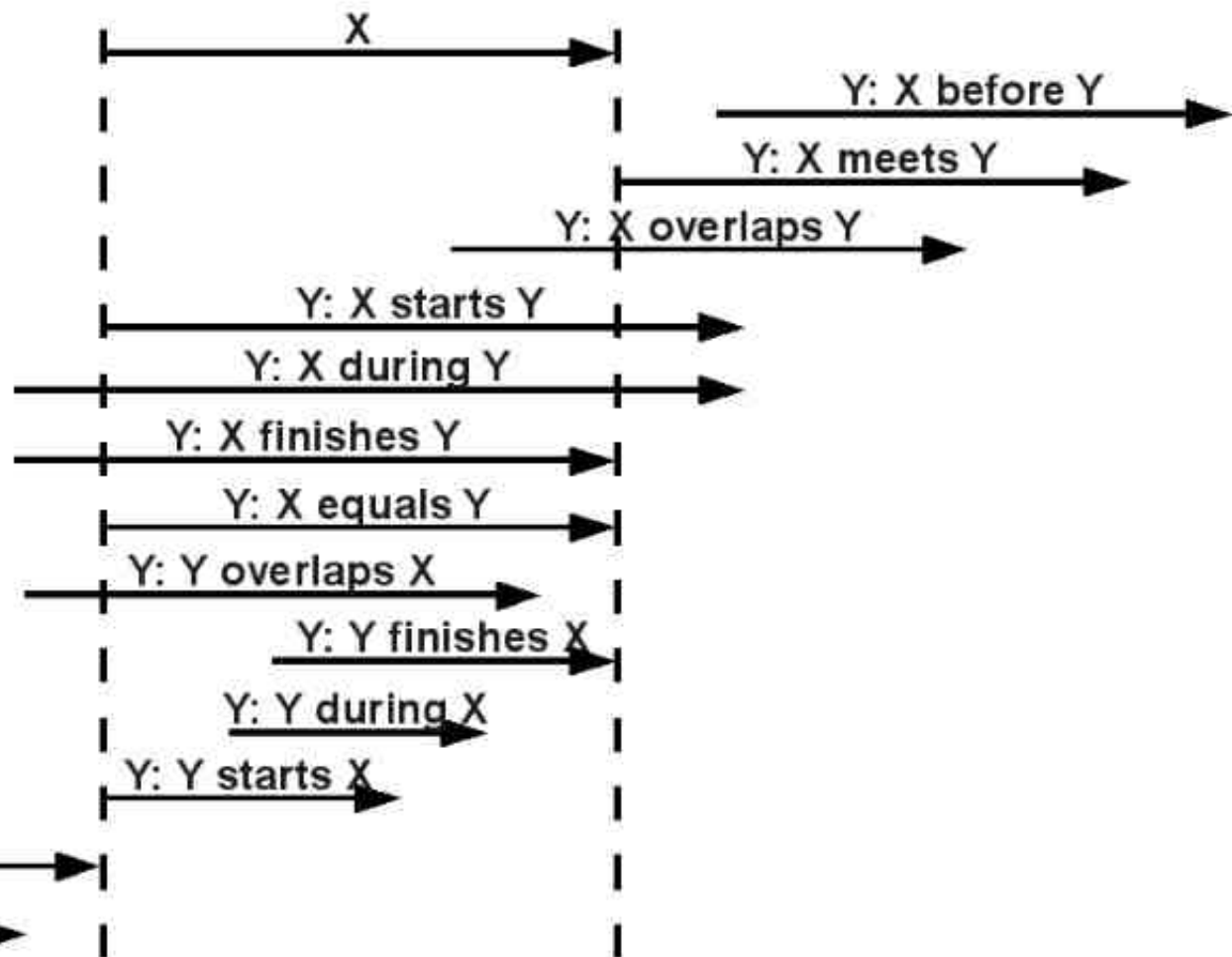
X = interval of utterance event by speaker A

Y = interval of utterance event by speaker B

Speech Production

X = interval of a syllable / vowel

Y = interval of a pitch accent



Phonological theories based on temporal relations

- Steven Bird & Ewan Klein:
 - Bird, S. & Klein, E. (1990). Phonological events. *Journal of Linguistics* , 26 , 33–56.
- Julie Carson-Berndsen:
 - Carson-Berndsen, J.; (1998) *Time Map Phonology: Finite State Models and Event Logics in Speech Recognition*. Dordrecht Kluwer Academic Publishers.

Prosodic Hierarchy

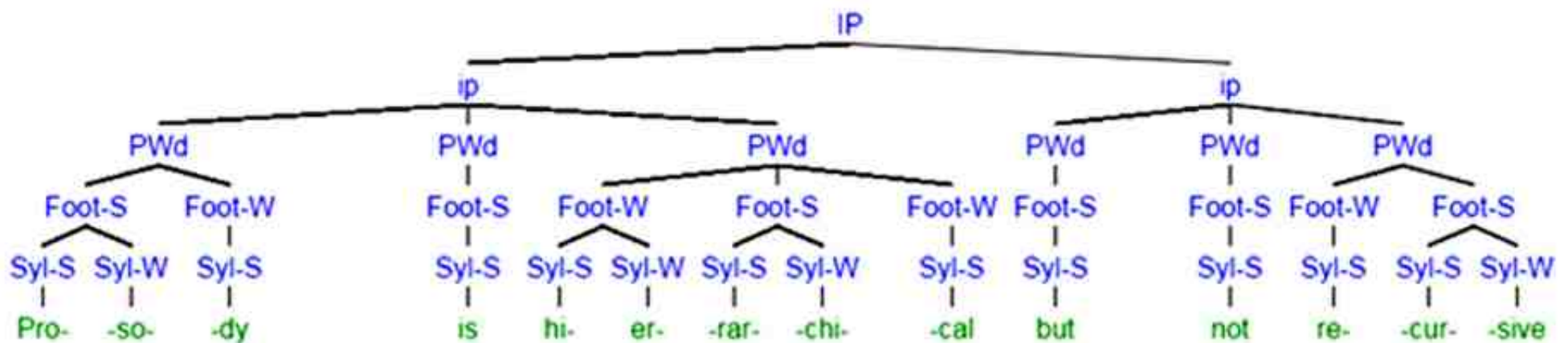
(a syntagmatic hierarchy)

Phonological Hierarchy – Prosodic Hierarchy

- The Prosodic Hierarchy is implicitly contained in the Rank Interpretation Architecture:
 - Prosodic hierarchy of associated units:
 - phonological segment – vowels, consonants; distinctive features
 - syllable – stress, accent, tone
 - foot – basic unit of rhythm in stress languages
 - prosodic word – domain of lexical phonological rules
 - prosodic phrase – domain of intonation: onset – body - nucleus
 - paratone – (larger intonation domain, analogous to ‘paragraph’)

Phonological Hierarchy – Prosodic Hierarchy

- Intonation Phrase (IP)
- Intermediate Phrase (ip)
- Phonological Word (PWd)
- Foot: strong | weak (Foot, Foot-S, Foot-W)
- Syllable: strong | weak (Syl, Syl-S, Syl-W)



Heffner, Christopher C. and L. Robert Slevc. 2015. Prosodic Structure as a Parallel to Musical Structure. In: Hypothesis and Theory. *Frontiers in Psychology*. Volume 6 (doi:10.3389/fpsyg.2015.01962), p.3, Fig. 1.

The Prosodic Hierarchy: an integrative view

Utterance (Utt): constituent of turn-taking, Q&A etc.

Intonational Phrase (IP): boundary tones, association with

Sentential domain prosody

Phonological phrase (PhP), Intermediate Phrase (ip): phrase boundary tone, domain of phrase stress

Phonological word, Prosodic Word (PW, PrWd, ω): domain of word stress, prosodic morphology, clitics

Foot (φ): Domain of primary, secondary, fixed stress, prosodic

Lexical domain prosody

Syllable (σ): phonotactic patterns, stress-bearing unit, (phonetically: local sonority peak)

Mora (μ): tone placement, phonotactic patterns

Segment: smallest 'leaf' element in prosodic hierarchy

Subsegment: affricates, diphthongs; (phonetic: stop closure-pause-release)

The Prosodic Hierarchy: an integrative view

Utterance (Utt): constituent of turn-taking, Q&A etc.

Intonational Phrase (IP): boundary tones, association with

Sentential domain prosody

Phonological phrase (PhP), Intermediate Phrase (ip): phrase boundary tone, domain of phrase stress

Phonological word, Prosodic Word (PW, PrWd, ω): domain of word stress, prosodic morphology, clitics

Foot (φ): Domain of primary, secondary, fixed stress, prosodic morphology

Syllable (σ): phonotactic patterns, stress-bearing unit, (phonetically: local sonority peak)

Mora (μ): tone placement, phonotactic patterns

Segment: smallest 'leaf' element in prosodic hierarchy

Subsegment: affricates, diphthongs; (phonetic: stop closure-pause-release)

The Prosodic Hierarchy: an integrative view

Utterance (Utt): constituent of turn-taking, Q&A etc.

Intonational Phrase (IP): boundary tones, association with grammatical phrase

Phonological phrase (PhP), Intermediate Phrase (ip): phrase boundary tone, domain of phrase stress

Phonological word, Prosodic Word (PW, PrWd, ω): domain of word stress, prosodic morphology, clitics

Foot (φ): Domain of primary, secondary, fixed stress, prosodic morphology

Lexical domain prosody

Syllable (σ): phonotactic patterns, stress-bearing unit, (phonetically: local sonority peak)

Mora (μ): tone placement, phonotactic patterns

Segment: smallest 'leaf' element in prosodic hierarchy

Subsegment: affricates, diphthongs; (phonetic: stop closure-pause-release)

The Prosodic Hierarchy: an integrative view

Utterance (Utt): constituent of turn-taking, Q&A etc.

Intonational Phrase (IP): boundary tones, association with grammatical phrase

Phonological phrase (PhP), Intermediate Phrase (ip): phrase boundary tone, domain of phrase stress

Phonological word, Prosodic Word (PW, PrWd, ω): domain of word stress, prosodic morphology, clitics

Foot (φ): Domain of primary, secondary, fixed stress, prosodic morphology

Syllable (σ): phonotactic patterns, stress-bearing unit, (phonetically: local sonority peak)

Mora (μ): tone placement, phonotactic patterns

Segment: smallest 'leaf' element in prosodic hierarchy

Subsegment: affricates, diphthongs; (phonetic: stop closure-pause-release)

The grammar of the Prosodic Hierarchy

Prosodic Category inventory:

PC = {Utt, IP, PhP, PrWd, omega, Ft phi, syll, mora, segment}

Prosodic Hierarchy ordering:

L = <Utt, IP, PhP, PrWd, omega, Ft phi, syll, mora, segment>

I1 = Utt, I2 = IP, ... I9 = segment

Structural constraints on Prosodic Hierarchy

Strict Layering Hypothesis:

PC at L_i dominates only PCs at L_{i+1}

- Fixed depth (no recursivity): No PC at L_i dominates a PC at L_{i+1}
- Exhaustivity: All PCs at L_i are dominated by a single PC at L_{i-1}

Headedness:

- Every PC at L_i immediately dominates a PC at L_{i+1}

The grammar of the Prosodic Hierarchy

Prosodic Category inventory:

PC = {Utt, IP, PhP, PrWd, omega, Ft phi, syll, mora, segment}

Prosodic Hierarchy ordering:

L = <Utt, IP, PhP, PrWd, omega, Ft phi, syll, mora, segment>

I1 = Utt, I2 = IP, ... I9 = segment

Structural constraints on Prosodic Hierarchy

Strict Layering Hypothesis:

PC at L_i dominates only PCs at L_{i+1}

- Fixed depth (no recursion): No PC at L_i dominates a PC at L_{i+1}
- Exhaustivity: All PCs at L_i are dominated by a single PC at L_{i-1}

Headedness:

- Every PC at L_i immediately dominates a PC at L_{i+1}

But iterative recursion at the same rank is ok.

Summary

Topics covered:

- Prosodic phonology as prosodic knowledge
- Methods of prosodic phonology
- Phonological approaches:
 - Finite state phonologies
 - Event phonologies
 - Hierarchical phonologies