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

Grammar – compositionality

LEXICON – holistic properties, opacity

MORPHO)PHONEME
MORPHEME
LEXICAL ROOT
DERIVED WORD
COMPOUND WORD
PHRASE
CLAUSE
SENTENCE
TEXT
DISCOURSE

Interpretations

SEMANTICS/PRAGMATIC HIERARCHIES:

- concepts
- objects
- events

MULTIMODAL HIERARCHIES:

- speech
- writing
- gesture

semiotic relation between meaning and phonetic form
## Prosody in the Ranks and Interpretations Model

### Rank

<table>
<thead>
<tr>
<th>Grammar – compositionality</th>
<th>Prosodic-phonetic Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISCOURSE</td>
<td>discourse rank: intonation, rhythm</td>
</tr>
<tr>
<td>TEXT</td>
<td>utterance rank: intonation, rhythm</td>
</tr>
<tr>
<td>SENTENCE</td>
<td>sentence, clause, phrase rank: intonation, rhythm</td>
</tr>
<tr>
<td>CLAUSE</td>
<td>phrasal accent, boundary tone</td>
</tr>
<tr>
<td>PHRASE</td>
<td>word rank: morphological tone/accent/stress</td>
</tr>
<tr>
<td>COMPOUND WORD</td>
<td>phoneme rank: segment/tone/accent/stress</td>
</tr>
<tr>
<td>DERIVED WORD</td>
<td></td>
</tr>
<tr>
<td>LEXICAL ROOT</td>
<td></td>
</tr>
<tr>
<td>MORPHEME</td>
<td></td>
</tr>
<tr>
<td>(MORPHO)PHONEME</td>
<td></td>
</tr>
</tbody>
</table>
Prosodic Knowledge

Knowledge is neither objective nor permanent

Why? Because ...

Knowledge is a multidimensional function of

observational method
selected domain
representation
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Everyday knowledge and scientific knowledge
differ along these three dimensions
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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

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    - 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

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

\[
\begin{array}{cccc}
\text{Pre- Head} & \text{Break} & \text{Nucleus} & \text{Tail} \\
\text{head (taktkopf)} & \text{(neuanhebung)} & \text{(tiefton)} & \text{(abtakt)}
\end{array}
\]

IG → NonFinal* Final

NonFinal → Bk Ana* Accent (Str)* Unstr

Final → Ana* Nucleus Unstr*

Top: Klinghardt & Klemm (1920)
Bottom: Armstrong & Ward (1926)
Graphical ‘iconic’ transcription

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

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\begin{array}{c}
\text{Pre-} \\
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\text{head (auftakt)} \\
\end{array}

\begin{array}{c}
\text{Break} \\
\text{(neuanhebung)} \\
\end{array}

\begin{array}{c}
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\text{Tail (tiefton)} \\
\end{array}

(5) it was 'ten o’clock on a 'cold December morning

\begin{array}{c}
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\text{head (auftakt)} \\
\end{array}

\begin{array}{c}
\text{(Head)} \\
\text{(Nucleus)(Tail)} \\
\end{array}

\begin{array}{c}
\text{Break} \\
\end{array}

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

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Pedagogical and practical notations

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  - named height of accent on perceived pitch scale:

  \[
  \begin{array}{cccccccc}
  \text{H*} & \text{L*} & \text{L*H} & \text{LH*} & \text{H*L} & \text{HL*} & \text{H*H} \\
  \end{array}
  \]

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

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Early phonological representations

- Tonetic stress marks and tone group structure
  - here: O’Connor & Arnold 1961

Early phonological representations

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

\[
\text{IG} \rightarrow (\text{Prehead}) (\text{Head}) \text{ Nucleus} (\text{Tail})
\]

\[
\text{Head} \rightarrow \text{Accented syllable}
\]

\[
\text{every other syllable in the Head is unaccented}
\]

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

- **H***: Shape=point, Place=high
- **L***: Shape=point, Place=low
- **L***H: Shape=rise, Anchor=start, Place=high
- **LH***: Shape=fall, Anchor=start, Place=high
- **H***L: Shape=fall, Anchor=end, Place=low
- **HL***: Shape=level, Anchor=start, Place=high
- **H***H: Shape=level, Anchor=end, Place=low
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):
- Boundary Tone: { H%, %L% }

Categorial interpretation (prosodic phonologies):
- Configurative: Initial/final boundary; ip, IP boundary
- Contrastive: accents
- Culminative: accent placement

Contour parsing (Tonetics):
- Prehead head body nucleus tail
Prosodic Phonology as the Grammar of Prosody
Basic principles

GRAMMAR:

syntagmatic relations
paradigmatic relations

semantic-pragmatic interpretations

modality interpretations
Basic principles

PHONOLOGY
(grammer of sound patterns in words):
syntagmatic relations
paradigmatic relations

semantic-pragmatic interpretations

modality interpretations
Basic principles

PROSODIC PHONOLOGY
(grammar of all sound patterns including intonation):
- syntagmatic relations
- paradigmatic relations

semantic-pragmatic interpretations

modality interpretations
Grammar of English intonation:
Finite State models of syntagmatic relations
Syntagmatic structure: a Finite Machine Model

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

Pierrehumbert (1980)

\[ \text{IP} \rightarrow \text{BT}_1 \text{ PAcc}^+ \text{ PhAcc} \text{ BT}_2 \]

\[ \text{BT}_1, \text{BT}_2 \in \{\text{H\%}, \text{L\%}\} \]

\[ \text{PAcc} \in \{\text{H\ast}, \text{L\ast}, \text{L\ast}^+\text{H\textendash}, \text{L\textendash}^+\text{H\ast}, \text{H\ast}^+\text{L\textendash}, \text{H\textendash}^+\text{L\ast}, \text{H\ast}^+\text{H\textendash}\} \]

\[ \text{PhAcc} \in \{\text{H\textendash}, \text{L\textendash}\} \]
Syntagmatic structure: a Finite Machine Model

Revisions needed to this model:

1. Reset (internal 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

18c. kOdONarike JazI wuro ta si?
rire comme si le roi n’était pas mort!

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
^l and l 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

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Sino-Tibetan tone

- Tianjin Mandarin
Tone sandhi in Chinese tonal systems: Tianjin Mandarin

Sequential and simultaneous syntagmatic relations: 

de 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:

![Diagram showing 13 possible relations between intervals](image)
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:

• Julie Carson-Berndsen:
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)

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)
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**Lexical domain prosody**

**Segment:** smallest 'leaf' element in prosodic hierarchy

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The grammar of the Prosodic Hierarchy

Prosodic Category inventory:

\[ PC = \{\text{Utt, IP, PhP, PrWd, omega, Ft phi, syll, mora, segment}\} \]

Prosodic Hierarchy ordering:

\[ L = <\text{Utt, IP, PhP, PrWd, omega, Ft phi, syll, mora, segment}> \]
\[ l_1 = \text{Utt}, l_2 = \text{IP}, \ldots l_9 = \text{segment} \]

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 \( L_{i+1} \)
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Headedness:

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

But iterative recursion at the same rank is ok.
Summary

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