

# Rhythm

An interactive introduction

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Ak-Phon 2005-07-13

# Overview

- Definitions and examples of rhythm
- Emergent Rhythm Theory (ERT)
- Timing factors in linguistics and phonetics
  - Levels of patterning and isochrony
- Phonological rhythm theories
  - Metrical Phonology, Prosodic Hierarchy
- Phonetic rhythm theories
  - Patterns: Pike, Abercrombie, Jassem
  - Global isochrony: Isard, Roach, ...
  - Global pattern ratio: Ramus, ...
  - Local linear: Low & Grabe
- A new strategy
  - Measuring rhythm types
  - Inducing hierarchical temporal patterns

# Presentation strategy

- Lecture: introduction to
  - basic concepts
  - approaches
- Discussion: intuitive explicanda for “rhythm”
- Method practice:
  - temporal annotation (with annotation software)
    - selection of units – C/V clusters, syllables, feet
  - manual analysis of annotation (with spreadsheet)
    - mean durations
    - variance & standard deviation of durations
    - Low & Grabe PVI (pairwise variability index)
    - Gibbon TPA (temporal periodicity analysis)

# Rhythm definitions & examples

Etymology: Middle French & Latin; Middle French rythme, from Latin rhythmus, from Greek rhythmos, probably from rhein to flow -- more at STREAM

- 1 a : an ordered recurrent alternation of strong and weak elements in the flow of sound and silence in speech b : a particular example or form of rhythm <iambic rhythm>
- 2 a : the aspect of music comprising all the elements (as accent, meter, and tempo) that relate to forward movement b : a characteristic rhythmic pattern <rumba rhythm>; also : 1METER 2 c : the group of instruments in a band supplying the rhythm -- called also rhythm section
- 3 a : movement or fluctuation marked by the regular recurrence or natural flow of related elements b : the repetition in a literary work of phrase, incident, character type, or symbol
- 4 : a regularly recurrent quantitative change in a variable biological process <a circadian rhythm> -- compare BIORHYTHM
- 5 : the effect created by the elements in a play, movie, or novel that relate to the temporal development of the action

# Rhythm definitions & examples

*Rhythm* in general...

Rhythms in particular:

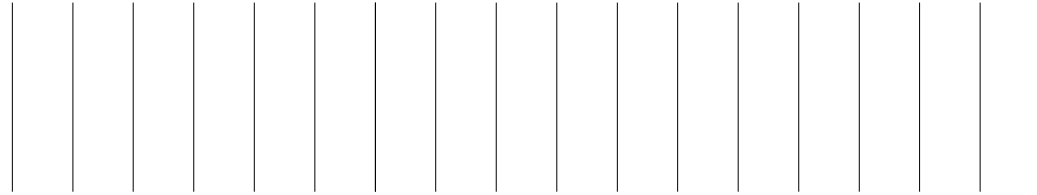
- Acoustic
- Visual
- Patterns:
  - trochaic
  - iambic
  - dactylic
  - anapaestic
- Complex:
  - beat
  - heterodyne
  - moiré

# What makes rhythm?

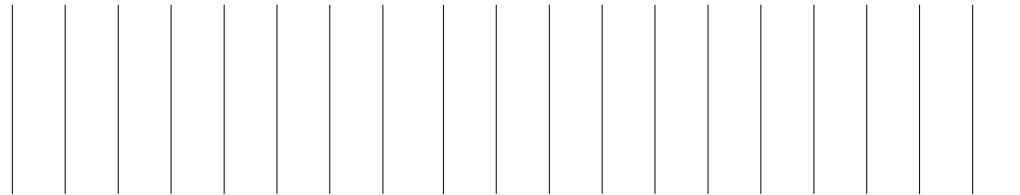
- Basic position:
  - rhythm is *emergent* i.e. a function of many different factors, e.g.
    - cognitive expectations
    - “biological clocks”
    - Temporal properties of prosodic hierarchies - cf. Tillmann's
      - A prosody: timing level of phonemes
      - B prosody: timing level of syllables, words
      - C prosody: timing level of phrases
    - Articulatory constraints (elastic tissues, weight of bones, ...)
    - Acoustic patterns
    - Integrative powers of the ear and hearing
- Pragmatic position:
  - this is all too complicated
  - let's concentrate first on what we can measure, for heuristic reasons (without rejecting other dimensions)

# Emergent complex rhythms (1)

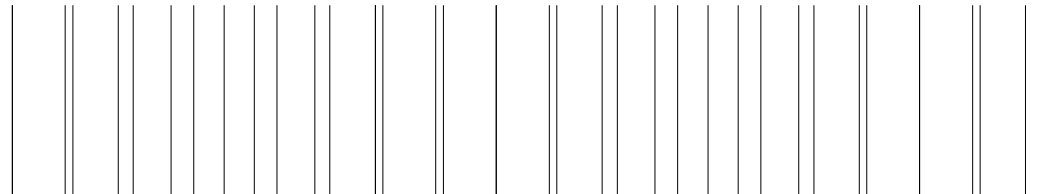
Rhythm 1:



Rhythm 2:

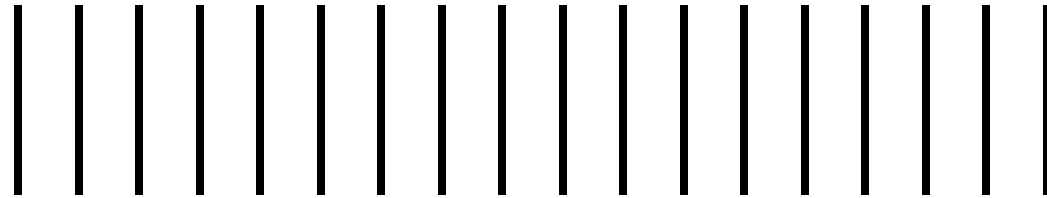


Rhythm 3:

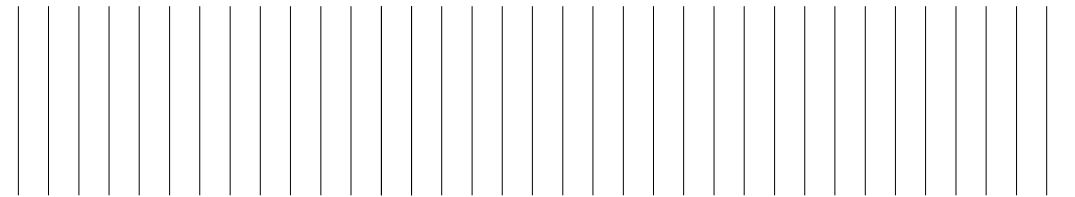


# Emergent complex rhythms (2)

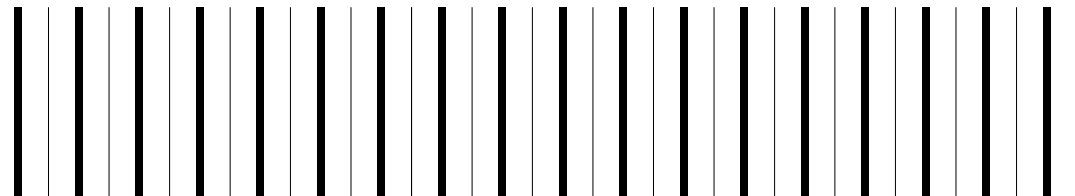
Rhythm 1:



Rhythm 2:



Rhythm 3:





# Timing factors in speech

- Phrase:
  - Speech tempo
  - Parenthetic speech
  - Emphatic accent
  - Focal / contrastive accent
  - Phrasal accent (realisation of sentence stress)
- Word:
  - Accent (realisation of word stress)
  - Word stress
  - Foot: speech tempo
  - Syllable: strong/long – weak/short syllables
  - C & V contrastive phoneme durations
  - Allophonic duration variation (e.g. Eng. V[+st])

# Phonological rhythm theories

- Syllable vs. Stress/Foot timing
  - Pike
  - Abercrombie
- Stratified hierarchies:
  - Jassem
  - Prosodic Hierarchies
    - Selkirk, Hayes
    - Campbell
- General hierarchies:
  - Metrical Phonology

# Phonetic rhythm theories

- Global:
  - variance, standard deviation (isochrony):
    - Isard
    - Roach
  - peak-trough ratio:
    - Ramus
  - Periodicity Analysis
    - Gibbon
- Local:
  - peak-trough alternation ratio:
    - Low, Grabe & Nolan (PVI)
    - Gibbon & Gut (RR)
    - Gibbon (Time Tree Induction)
- Dynamic:
  - Barbosa, Cummins, Wachsmuth, ...

# Practical: annotation & analysis

- Choose a short speech file
- Annotate the following tiers with Praat:
  - Phonemes
  - Syllable
  - Feet
- The following can be done automatically, but...
  - Enter the time-stamps for each tier into separate worksheets of a spreadsheet program (OpenOffice Calc, Excel)
  - For each tier:
    - calculate average length (AL) of units
    - calculate standard deviation (SD) of units
    - normalise by dividing SD/AL (0 = isochrony)

# Average length and speech rate

| Phon |       | Syll |       | Foot |       |
|------|-------|------|-------|------|-------|
|      | 80    |      | 250   |      | 473   |
|      | 170   |      | 100   |      | 420   |
|      | 40    |      | 123   |      |       |
|      | 60    |      | 300   |      |       |
|      | 60    |      | 120   |      |       |
|      | 63    |      |       |      |       |
|      | 110   |      |       |      |       |
|      | 140   |      |       |      |       |
|      | 50    |      |       |      |       |
|      | 70    |      |       |      |       |
| AL   | 84,3  |      | 178,6 |      | 446,5 |
| Rate | 11,86 |      | 5,6   |      | 2,24  |

AL: Average Length (in msec)

Rate:  $1000 / \text{AL}$  (in sec)

SD: Standard Deviation

# NDI: an isochrony measure

| Phon    | Syll  | Foot  |
|---------|-------|-------|
| 80      | 250   | 473   |
| 170     | 100   | 420   |
| 40      | 123   |       |
| 60      | 300   |       |
| 60      | 120   |       |
| 63      |       |       |
| 110     |       |       |
| 140     |       |       |
| 50      |       |       |
| 70      |       |       |
| AL 84,3 | 178,6 | 446,5 |
| SD 42,3 | 90,19 | 37,48 |
| NDI 0,5 | 0,51  | 0,08  |

SD: Standard Deviation

AL: Average Length

$NDI = SD / AL$ : Normalised Deviation Index ( $\geq 0$ )

Perfect isochrony:  $NDI = 0$

# PVI: a binary alternation measure

| Phon       | $\Delta\text{dur}$ | $ \Delta\text{dur} $ | AVG    | $ \Delta\text{dur} /\text{AVG}$ | Syll   | $\Delta\text{dur}$ | $ \Delta\text{dur} $ | AVG    | $ \Delta\text{dur} /\text{AVG}$ | Foot   | $\Delta\text{dur}$ | $ \Delta\text{dur} $ | AVG    | $ \Delta\text{dur} /\text{AVG}$ |
|------------|--------------------|----------------------|--------|---------------------------------|--------|--------------------|----------------------|--------|---------------------------------|--------|--------------------|----------------------|--------|---------------------------------|
| 80,00      | -90,00             | 90,00                | 125,00 | 0,72                            | 250,00 | 150,00             | 150,00               | 175,00 | 0,86                            | 473,00 | 53,00              | 53,00                | 446,50 | 0,12                            |
| 170,00     | 130,00             | 130,00               | 105,00 | 1,24                            | 100,00 | -23,00             | 23,00                | 111,50 | 0,21                            | 420,00 | 420,00             | 420,00               | 420,00 | 1,00                            |
| 40,00      | -20,00             | 20,00                | 50,00  | 0,40                            | 123,00 | -177,00            | 177,00               | 211,50 | 0,84                            |        |                    |                      |        |                                 |
| 60,00      | 0,00               | 0,00                 | 60,00  | 0,00                            | 300,00 | 180,00             | 180,00               | 210,00 | 0,86                            |        |                    |                      |        |                                 |
| 60,00      | -3,00              | 3,00                 | 61,50  | 0,05                            | 120,00 |                    |                      |        |                                 |        |                    |                      |        |                                 |
| 63,00      | -47,00             | 47,00                | 86,50  | 0,54                            |        |                    |                      |        |                                 |        |                    |                      |        |                                 |
| 110,00     | -30,00             | 30,00                | 125,00 | 0,24                            |        |                    |                      |        |                                 |        |                    |                      |        |                                 |
| 140,00     | 90,00              | 90,00                | 95,00  | 0,95                            |        |                    |                      |        |                                 |        |                    |                      |        |                                 |
| 50,00      | -20,00             | 20,00                | 60,00  | 0,33                            |        |                    |                      |        |                                 |        |                    |                      |        |                                 |
| 70,00      |                    |                      |        |                                 |        |                    |                      |        |                                 |        |                    |                      |        |                                 |
| <b>AVG</b> |                    |                      |        | <b>0,50</b>                     |        |                    |                      |        | <b>0,69</b>                     |        |                    |                      |        | <b>0,56</b>                     |
| <b>PVI</b> |                    |                      |        | <b>49,68</b>                    |        |                    |                      |        | <b>68,94</b>                    |        |                    |                      |        | <b>55,94</b>                    |

PVI:

$$100 * \text{AVERAGE}(\text{ABSOLUTE}(\text{diff}_i - \text{diff}_{i+1}) / \text{AVERAGE}(\text{diff}_i, \text{diff}_{i+1}))$$

# Perspective...

- Implementation and further development dynamic approaches:
  - Barbosa
  - Cummins
  - Wachsmuth
- Development of rhythm typology measures:
  - unary (cf. syllable timing)
  - binary: iambic, trochaic
  - ternary: dactylic, anapaestic
  - other ...
- Relation of phonetic patterns to patterns of
  - phonology
  - morphology
  - phrasal syntax
  - discourse