Review/discussion of 2 papers by Bruce Richman† on vocal abilities of gelada monkeys

Bruce Richman (1976) Some vocal distinctive features used by gelada monkeys. *Journal of the Acoustical Society of America* 60 (3), 718-724.

Bruce Richman (1987) Rhythm and Melody in Gelada Vocal Exchanges. *Primates* 28(2), 199-223.

† deceased 4/10/2007

Why?

Complexity

Human vocalisation (“language”) more complex than non-human vocalisations

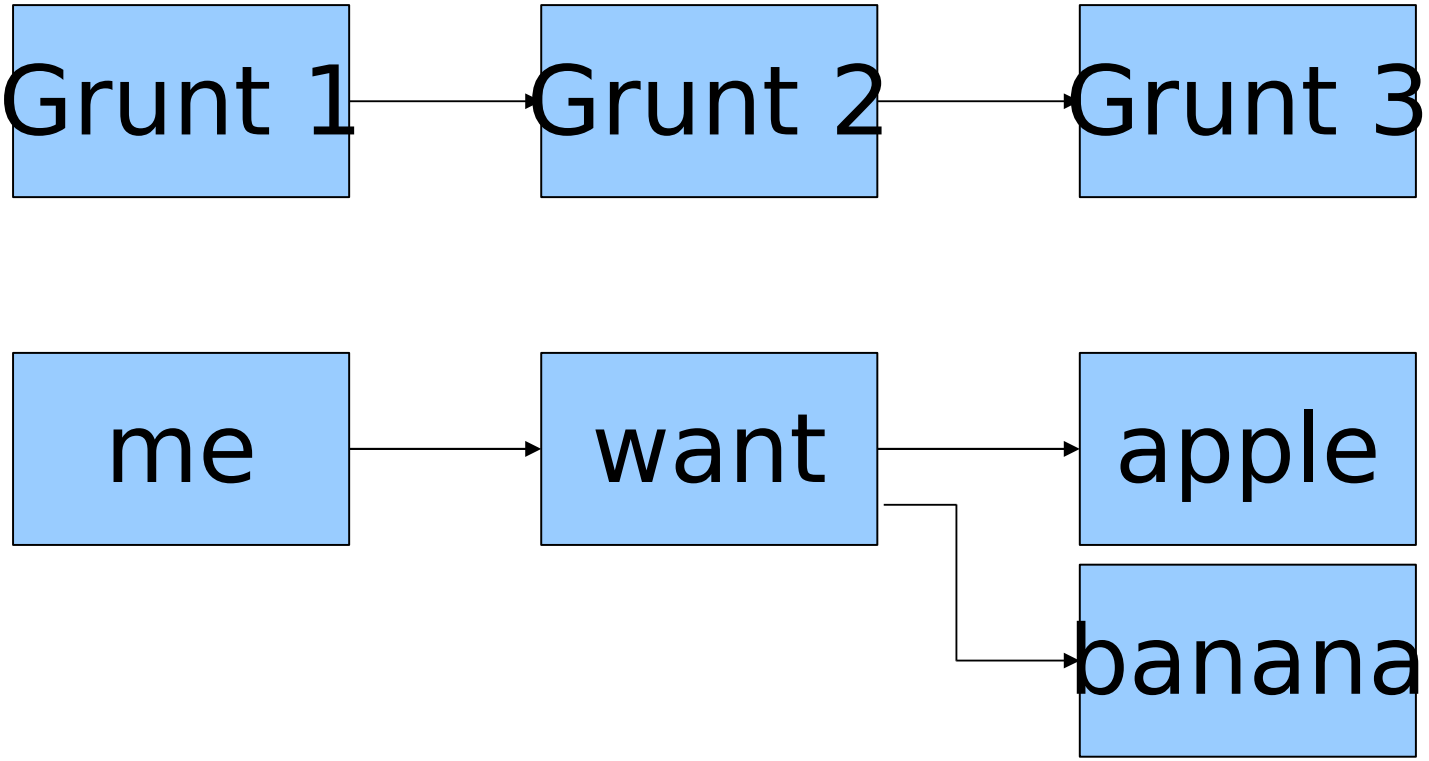
- rich spectral distinctions in sounds
- tens of elementary sounds
- groups of several sounds combined into 10,000's of significant (meaningful) elements
- groups of (tens of) meaningful elements combined into longer signals with more complex meaning

Human vocalisation (“language”) more complex than non-human vocalisations

- complexity of sequences
- chains (finite-state machines, Markov processes etc)
- chains grouped into 'phrases'
- phrases embedded within phrases

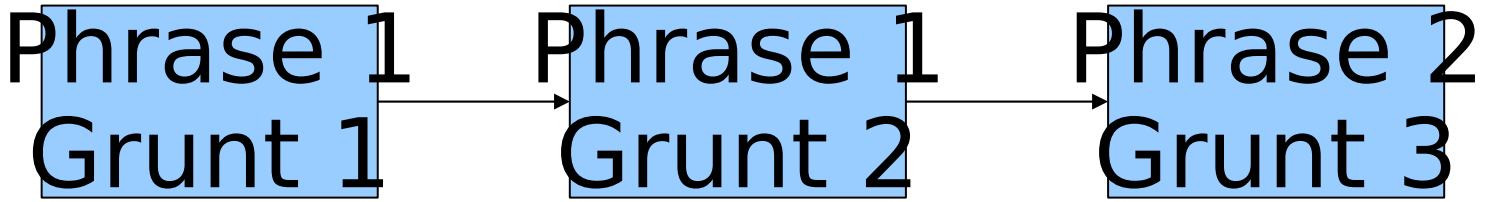
Complexity of sequences

- chains (finite-state machines, Markov processes etc)



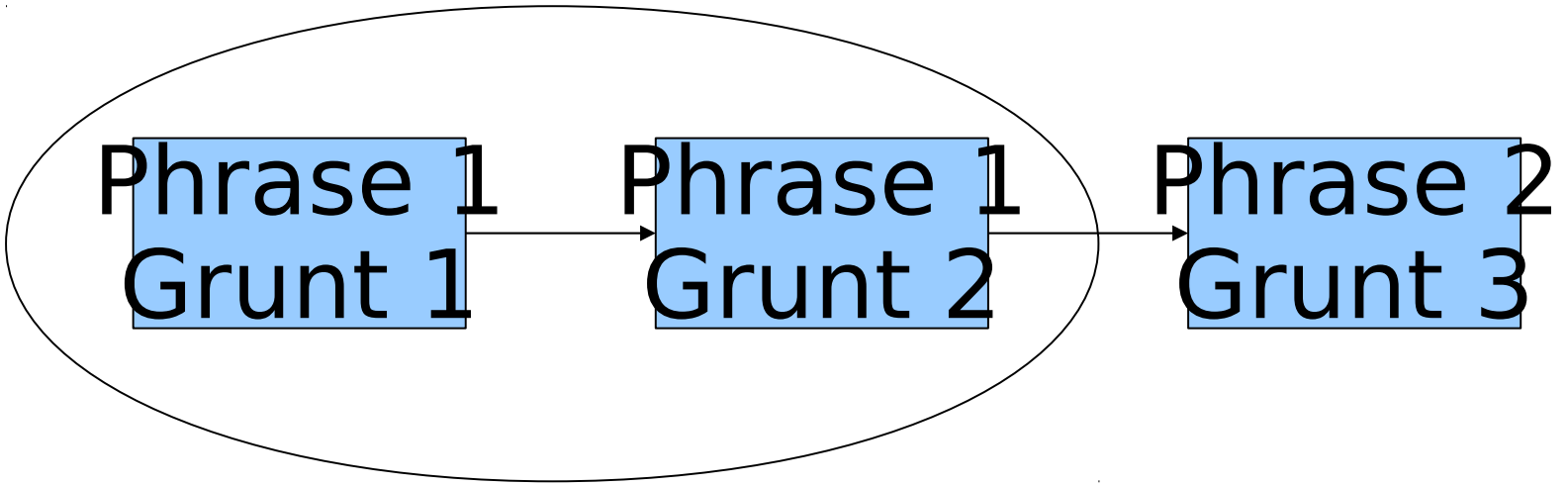
Complexity of sequences

- chains (finite-state machines, Markov processes etc)
- chains grouped into 'phrases'



Complexity of sequences

- chains (finite-state machines, Markov processes etc)
- chains grouped into 'phrases'



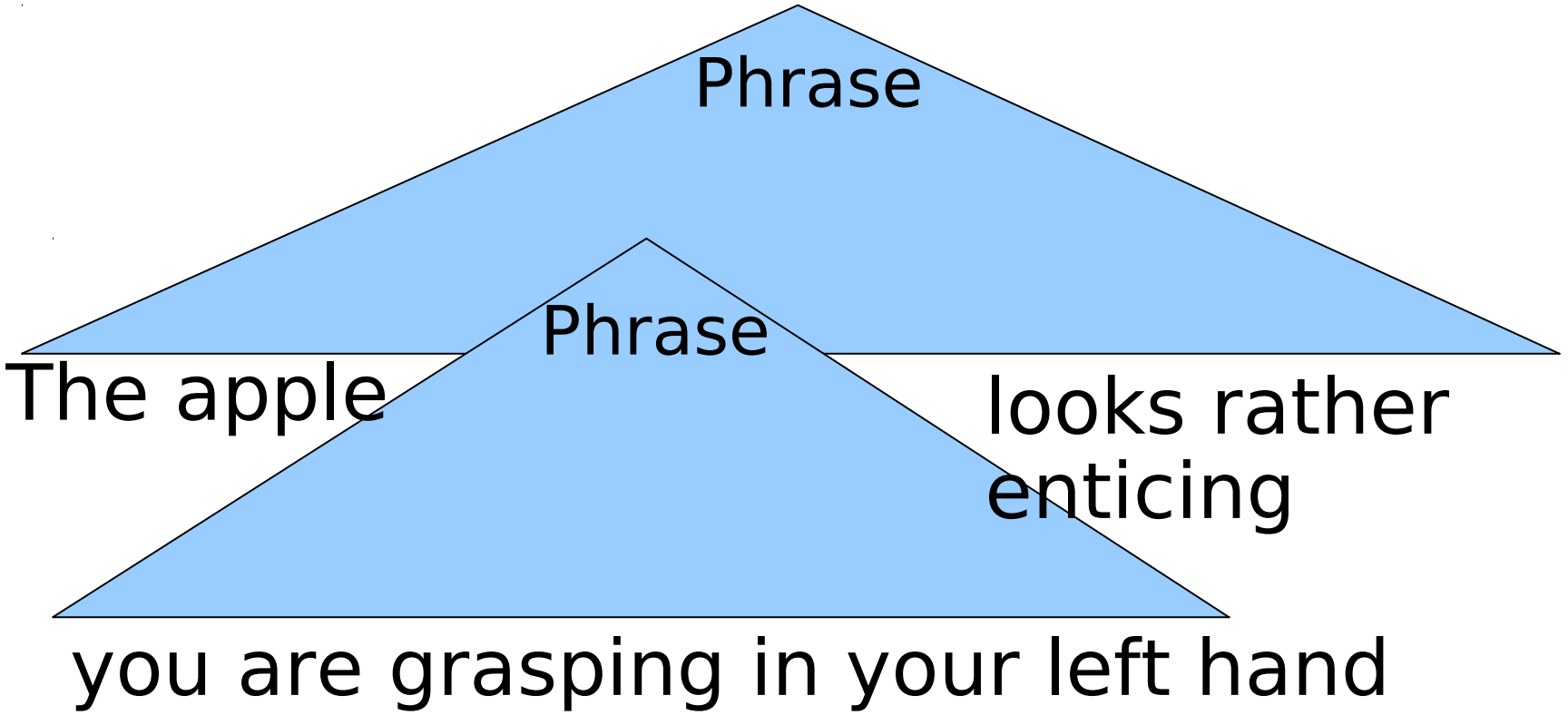
Complexity of sequences

- chains (finite-state machines, Markov processes etc) can't encode certain more complex sequences
- Holy and Guo (2005) Ultrasonic songs of male mice *PLoS Biology* 3 (12) e386

“the transition-probability model ... is insufficient ($p \approx 10^{-6}$) to capture all of the higher-order structure of these three-syllable sequences. Similar conclusions apply to four- and five-syllable sequences.2”

Complexity of sequences

- phrases embedded within phrases



Large inventory of distinct sounds

- 3 airstream mechanisms
- 2 airflow directions
- 5 distinct laryngeal configurations
- 6 quasi-independent articulators
- 10 places of articulation
- 6+ degrees of constriction
- temporal contrasts (e.g. rate of release, duration, pitch changes)

Large inventory of distinct sounds

- Chimpanzees, dogs etc
- flat, less mobile tongue
- high larynx
- chimps have *more complex* but less controllable larynges
- which is why the Gardners decided to use manual signs with Washoe

Large inventory of distinct sounds

- human languages allow a vast space of combinatorial possibilities
- but the actual range of “appropriate” utterances seems highly constrained by the social context

Large inventory of distinct sounds

Richman (1976)

If it can be shown that nonhuman primates can produce vocal contrasts analogous to human distinctive features, the whole question of the vocal abilities of primates must be reassessed.

Gelada monkeys produce a range and abundance of sounds that is truly remarkable. Almost all their on-going social actions, in the complicated alliances and coalitions that make up their social groups, are accompanied by an astonishing variety and richness of sounds. As they approach one another, walk past one another or take leave of one another, as they start or stop social grooming, as they threaten someone because he is too close to a partner, solicit someone's support or reassurance, in fact, as they do the indefinite variety of different social actions that make up the minute-to-minute substance of their social lives they always accompany these actions with vocalizing.

Contexts

- “one-male groups recorded during free social interaction”
- the bulk of vocal exchanges involved in the analyses are produced in relaxed, "friendly" social situations with the sound intensity not greater than that of normal conversational human speech

Contexts

The greatest range of vocal exchanges was recorded from an adult female gelada, "Lala," at the San Francisco Zoo. She would come over to the side of the cage (whenever I appeared at her cage) about 4 ft away. I could elicit the most remarkable range of vocal exchanges from her merely by my own imitations of gelada vocal productions. Playback of recordings of gelada vocal exchanges would not elicit such a response from her - only my direct contact in a social situation with her along with my own imitations seemed to elicit such a response.

Large inventory of distinct sounds

- 3 airstream mechanisms
- 2 airflow directions *Geladas also*
- 5 distinct laryngeal configurations
- 6 quasi-independent articulators
- 10 places of articulation
- 6+ degrees of constriction
- temporal contrasts (e.g. rate of release, duration, pitch changes)

Large inventory of distinct sounds

- Humans: 5 distinct laryngeal configurations
- *Geladas 3:*
- '*A very pure, almost musical sound with most of the energy concentrated in the bottom part of the spectrum - below about 1000 Hz*
- *Sounds in which fundamental frequency is lower and spectrum is richer in higher harmonics; presumably produced with a lax neutral glottis*
- *noisy glottis with nonperiodic pulsations*

Large inventory of distinct sounds

- 3 airstream mechanisms *not Geladas*
- 2 airflow directions *Geladas also*

- *But* human languages' use of ingressive air is mostly clicks and implosives, *not* pulmonic

Implosion? Explosion?

12a b c

“These long ingressive sounds after achieving extreme rounding at the points in Figs. 12(b) and 13(b), manifest complete closure (presumably at the lips) during the blank spaces between Figs. 12(b) and 12(c) and 13(b) and 13(e). Then at the points in Figs. 12(e) and 13(c) is heard a sudden consonantlike release of the closure. This ... sounds definitely labial.”

Large inventory of distinct sounds

- 6 quasi-independent articulators:

  larynx, velic (nasal aperture), lips,

  tongue root/pharynx, tongue dorsum, tongue tip

- *Geladas:* BR reports impressions of nasal vs. non-nasal vocalizations

Large inventory of distinct sounds

- 10 places of articulation
- Geladas: back vs. front vowel quality
- (JC) ? “velar”/“pharyngeal” vs. “palatal” vowels
- Labials: BR describes progressively rounded (diphthongs) vs. unrounded vowels, leading to complete labial closure and release
- BR “tight” vs “muffled” voice, analogous to pharyngealization and labialization

Large inventory of distinct sounds

- 6+ degrees of constriction
- stop, sonorant, fricative
- high, mid, low vowels
- Geladas: high vs. low vowels [i]- and [j]-like vs. [a]- ([*ɑ*]?) like
- Diphthongal “glides” (sonorant)

Large inventory of distinct sounds

- 6+ degrees of constriction
  - high, mid, low vowels
- stop, sonorant, fricative
- Diphthongal “glides” (sonorant)
- Complete closure after vowels, and stop-like onsets
- [h]-like and [f]-like fricative onsets
- [l]-like, [j]-like and [m]-like gradual onsets
- “velarlike” onsets (?[ɯ]-like?)

1987

“not just this abundance of segmental sounds and features, but a great variety of rhythms and melodies as well. Fast rhythms, slow rhythms, staccato rhythms, glissando rhythms; first-beat accented rhythms, end-accented rhythms; melodies that have evenly-spaced musical intervals covering a range of two or three octaves; melodies that repeat exactly, previously produced, rising or falling musical intervals; and on and on: geladas vocalize a profusion of rhythmic and melodic forms.”

Syllables

“in the gelada Long Series the motor, temporal coordination of the tongue protrusion movements and the grunt sounds seems perfectly developed to produce equally spaced syllables with consonantal onsets in the midst of longer grunts and inspired sounds ... The syllable has become an independent unit of vocal production for geladas.”

Latched turn-taking

“These Quick Call-Response exchanges are initiated by short grunts with quick rising pitch contours. The answering voice keeps the exchange going by producing short, quick rising pitch grunts as well. The accuracy of the precise timing involved in these exchanges is remarkable: the voices never overlap, even when three voices are alternating; and time intervals between voices are precisely repeated.”

Latched turn-taking

“Geladas must be able to listen very carefully to the sequences of others and spend considerable effort in "figuring out" what these other voices are doing in order for us to be able to explain how they are able to synchronize their own sound onsets with the upcoming onsets of other voices, how they can parallel the tonal movements of others, and how they can place their alternations at precisely repeated time intervals after other voices' sounds”

Some questions

- Correlations between sound contrasts and social/emotional functions?
- Inventory of sounds in other primate spp?