

Linguistic Stress and Attentional Modulation

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1) Working Hypothesis:

The formal properties of linguistic stress can be explained terms of ...

A. a definition of linguistic stress

Linguistic stress = conventionalized attention modulation at the level of the syllable.

B. the function of linguistic stress

Attention modulation is one strategy for governing focus on informationally important units

and

C. how stress develops historically

Attention modulation 'grows from' seeds of syllable-level prominence

2) What's stress?

- Minimal pairs:** noun vs. verb version of *permit*
- Cross-linguistic:** huge numbers of observations of stress spawned sub-field of Metrical Phonology.
- Sentential:** WE saw you vs. We SAW you vs. We saw YOU. (c.f. Kent & Netsell, 1971)

3) Some Properties of Linguistic Stress Systems: (culled from various sources, such as Hayes, 1995)

- Hierarchical Nesting:** There are implicational restrictions between the levels of stress such that higher levels require lower levels.
- Reduced Contrast:** Unstressed items can have fewer contrasts and are often the targets of lenition phenomena.
- Domain:** Stress is usually expressed over a syllable.
- Alternation:** Stressed and unstressed material tends to be collated.
- Spacing:** Stresses tend to be distributed evenly throughout the lexical material.
- Accent Location:** Stressed items often are selected as the site for pitch accent docking.
- Culminativity:** Stresses may bear a one-to-one relationship with some higher-level unit.
- Weight Sensitivity:** Stresses tend to fall on heavy syllables. Heavy syllables are ones with long vowels and sometimes ones with final consonants.
- Boundedness:** Stress location can be determined in relation to position within a morphological or lexical unit.
- Boundedness Variation:** Stress locations may either be determined by position in morpheme or by weight sensitivity.

A. a definition of linguistic stress

4) Traditional experimental observations (Fry, 1955, 1958, 1965):

- Perceptual cues to stress location include effects of
 - duration
 - amplitude
 - vowel quality
- Though largely cued by interpretation of fundamental frequency contour as indicating the presence of a pitch accent

5) Cross linguistic comparison: (de Jong & Zawaydeh, 1999, in review)

Results from lexically similar corpora

English stress	Arabic stress (de Jong & Zawaydeh, 1999)
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27% vowel lengthening	25% vowel lengthening
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Explicit raising of F1 for low vowels	Explicit raising of F1 for low vowels
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High & Low discourse-sensitive pitch accents	High & Low discourse-sensitive pitch accents
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6) Unifying descriptions:

Loudness

- Sweet (1892); Jones (1960): pulmonic force perceived as loudness
- Bloomfield (1933); Trager & Smith (1951)
- Lehiste (1970); Beckman (1986): a more durationally sophisticated form

Clarity

- Walker (1781); Jones (1960): prominence/accent = distinctness
- Swedish school: Ohman, 1967; Engstrand, 1988
- American speech: Kent & Netsell, 1971; Harris, 1978

7) Odd results:

- Vowel space expansion
- de Jong (1991, 1995) Articulatory modelling of speech timing: F1 differences are not due to durational lengthening
- Coarticulation suppression
- English – Arabic comparison of voicing effects

8) Response

- 'clarity' is a more complete description, subsuming loudness
- First attempt: stress as combination of increase in gestural activation and decrease in coarticulation (de Jong et al., 1993).
- More complete: equated to Lindblom (1990): "hyperarticulation localized to the syllable"

Hyperarticulation: functional shift toward 'listener-oriented' speech.

-> Or (de Jong, 1998): Hyperarticulation = more attention in production.

9) What about perception?

Parallels evident in Cole, et al, 1978, Cole and Jakimik, 1980; Bond and Garnes, 1980; Terken and Nootboom, 1987; "hyperperception localized to the syllable".

E.g., Cole & Jakimik:

- d) Have listeners detect deliberate misproductions of syllable initial consonants
- e) Misproduction perception: Stressed = 82%; Unstressed = 47%

A stress system:
a convention in which both speakers and listeners systematically pay more attention to certain syllables than to others

a) the function of linguistic stress

10) Attentional dynamics applied to speech. Work on attentional dynamics by Mari Jones, Gary Kidd, and others (Jones, 1976; Jones & Boltz, 1989; Jones & Yee, 1993; Kidd, 1993, 1994, 1995; Large & Jones, 1997).

- a) **Example:** Kidd, 1993: auditory acuity is better at time-points determined by rhythmic pattern
- b) **Attentional phenomena in the auditory domain** (Large & Jones, 1997):

* **attentional selectivity:** some parts of a stimulus are more readily acted upon than others

* **attentional capture:** parts which suddenly change in salient dimensions tend to garner such selective advantages

* **attentional integration:** aspects which get attended to as a unit are those which work together to define an object or event

* **temporal expectancy:** a pattern of events in time will tend to focus attention to particular up-coming times

11) General model: Part 1.

Stress means => some syllables within lexical items are attentionally selected

12) Property #1: Hierarchical Nesting: Results from a 1-dimensional scale (not interesting)

13) Property #2: Reduced Contrast. Expected as a phonologization of stress effects

-> E.g. Russian unstressed syllables contrast 3 vowels, while stressed syllables contrast 5. Earlier versions of the language had even distribution of vowel contrasts. Unstressed locations were left unattended enough for the transmission of some of the contrasts to be permanently disrupted.

-> E.g. English unstressed/stressed pairs:

"Mendel" vs. "Mendelian" -> spelling of second vowel maintained by morphological form with primary stress on vowel. Spellings of consistently unstressed items are horrendously difficult, since vowel contrasts are all but lost in the spoken language.

-> (Note: promotion is also possible. E.g. epenthetic vowels in Irish Gaelic are unstressed and perhaps redundantly carry consonant information (NiChiosan, pc). The lack

is not from loss of contrast but from never having contrasts. In Scottish Gaelic, such vowels have accrued contrasts in relation to increasing stress. Hebridean Gaelic stresses epenthetic vowels and expresses a full set of 9 vowels with them. Borgstrom, 1937; Bosch & de Jong, 1997, 1998)

14) General model: Part 2.

The **attentional selectivity** arises from

attentional capture: attracted to acoustic events where sudden changes take place

and applies according to

attentional integration: works on portions of speech which are auditorially cohere or intercorrelate

15) Property #3: Domain.

Stress has as its domain the syllable, because

- ➔ attentional selectivity is attracted toward events which involve sudden onsets in acoustic energy (attentional capture) and applies across acoustic properties which consistently work together (attentional integration).
- ➔ stress attracted to syllable onsets as points of sudden onset in acoustic energy C.f., thread of work on the p-center: Rapp, 1971; Pompino-Marschall, 1989; Fox & Lehiste, 1987; de Jong, 1994b; and Cummins & Port, 1998. This work indicates a particularly salient aspect of the signal for rhythmic alignment near the onset of the stressed vowel.
- ➔ stress associates with syllables, which are acoustic units in the low frequency range (C.f. Bertoncini et al.'s, 1995, work on neonate perception.)
- ➔ And, syllabic coordinations may be organized around temporal and spectral consistency (Goldstein, 1994). Note also here evidence for syllables as temporal constraints (Kent & Moll, 1975; de Jong, in press).

16) Property #4: Alternation.

Caveat: Lexical eurythmy is by no means universal in English, since there are numerous items in which consecutive syllables bear some degree of stress (*thirteen, Chinese, digest, antique, chimpanzee...*). Even in running speech such forms are often not rendered with stress alternation (Beckman, et al, 1990).

- ➔ since attention is relational, attentional selection in one location will reduce attention to other locations. Stressed syllables will tend to garner more attention over linguistic history at the cost of neighboring portions.

17) General model: Part 3.

Attentional modulation can be governed by **temporal expectancy**. High attention areas may, under appropriate conditions, come at temporally predictable intervals.

18) Property #5: Spacing.

Caveat: Irregular distribution of stresses is rampant in uncontrolled, natural speech (see, e.g. Beckman, et al, 1990). Regularity of distribution is most apparent in stylized, repetitive, and high-involvement speech (Cummins and Port, 1998).

- Oscillatory mechanisms which capture rhythmic production and perception (Jones & Yee, 1993; McAwley, 1995; Cummins & Port, 1998; Tajima, 1999; Kitahara, et al, 2000) produce temporal regularity distributed evenly over a long time period. Rhythmic regularity allows listeners to predict the temporal location of the next important item (Shields et al, 1974; Cutler, 1976; also for converse, see Pitt and Samuel, 1990)
- In oscillatory systems, stresses will tend to be equally distributed throughout an utterance, and intervening material will become distressed. This is a potential source for eurythmy effects.

19) General Model: Part 4.

Attentional modulation is a possible global pattern which, once conventionalized, characterizes the speaker's and hearer's strategies. Speakers take care to place important information at predictable locations which hearers know to attend to. A match between speaker and hearer makes the system functional.

20) Property #6: Accent Location

Accents help direct attention to syllables which are hyperarticulated by the speaker. Conversely, in a language like English where there are discourse-related contrasts in accent type (see, e.g. Pierrehumbert & Hirschberg, 1990), a stressed syllable is a particularly high attention area where such discourse markers would be well-placed.

21) Property #7: Culminativity.

To the extent that culminativity obtains in the lexical domain, it indicates a one-to-one relationship between attentional units and lexical items. This would seem to be a mechanism which allows speakers to present speech as a series of lexical access tasks for the listener. (C.f. Cutler and Norris (1988) in which single-stressed forms were processed more readily than forms with multiple stresses.)

22) Property #8: Weight Sensitivity

stress attracted to particular syllables which 'stick out' due to syllable weight: vowel length or consonant codas

BUT: why would consonant codas cause a syllable to 'stick out' perceptually?
AND: why would speakers of different languages differ in weight sensitivity?

b) How stress develops historically

23) Properties #8 - #10: Weight Sensitivity & Boundedness: Common current wisdom summarized by Hayes '95

- a) Stress location often is preferential as to what sort of syllable it resides on
- b) Formal property used to determine preference is "weight" (Newman, 1972)
- c) Weight is determined with respect to an implicational hierarchy of the following form:

Long vowels > Coda sonorants > Coda obstruents > Short vowels
so: [..V:C] > [..V:] > [..VR] > [..VO] > [..V]
(Vowel quality can sometimes be used as well.)

- d) Linguistic phonologies pick a particular criterion for light and heavy syllables
so: Language 1: [..V:C] & [..V:] >>>>> [..VC] & [..V]
but: Language 2: [..V:C] & [..V:] & [..VC] >>>>> [..V]
(Languages also might choose to define weight with different criteria altogether, such as using vowel quality.)

- e) This weight criterion is one of a small number of parameters which determine the metrical system of that language
 - weight sensitive: some syllables preferentially get stress
 - weight criterion: consonants might or might not count for weight
 - boundedness: stress is or is not restricted with respect to location in word
 - directionality: stress location is sometimes figured with respect to the beginning, and sometimes with respect to the end
 - 'foot type': stress may fall on even or odd numbered syllables

24) Shortcomings with formal factorial typology

- Survey of grammars by Gordon, 1999: Weight is not a property of a phonological system, but is idiosyncratic to particular rules such as stress rules.
- Survey of grammars by Ahn, 2000: Metrical systems are not (at all) evenly distributed across the types predicted by a parameterized metrical model.
- most languages are bounded
- beginning stress languages usually stress the first syllable, while end stress languages usually stress the second syllable from the end
- consonants only count in bounded systems. I.e. when stress falls on a heavy syllable, irrespective of that syllable's location in the word, the heavy syllable always has a long vowel

25) Lim (2000): Stress in Korean:

Polianov (1936)	End of Utter.	x [s...]
	Other-wise	x ...s]
Huh (1985); J-S. Lee (1992)		x [s...]
H-B. Lee (1974, 1985, 1989)	Long Vowel	x ... CV:...
	Heavy	x [s...]
	Light	x [ls...]
J. Yu (1989)	Heavy	Left-most
	Light	x ...s]
H-Y. Lee (1990), J-K. Kim (1998) TYPE 1 language (also Lim)	Heavy	x [s...]
	Light	x [ls...]

Or:

- Unpredicable accent (Zong, 1965, Cho, 1967)
- Korean has no stress (Jun, 1993, 1995, & deJong, 1994a)

26) Lim (2000): Production Results

- No systematic differences in vowel duration, except for phrase-level final lengthening.
- Vowel durations behaved the same for heavy and light syllables.

27) Lim (2000): Perception Results

- Two production conditions: Final and Non-final. So, intonational markers differed in the two conditions
- Three listener groups: English, Japanese, and Korean

Results:

- Japanese more sure than English or Korean listeners
- Koreans rather like Japanese - both tend to consistently hear 2nd syllable prominence
- English listeners very different, especially in non-final cases

Why?

- 2nd syllable prominence correlated with an F0 peak over the second syllable. Phrases get marked with a salient rise at the beginning of the accentual phrase.
- English listeners tend to interpret intonational 'continuation rises' as accent and so hear final stress

SOOOO...

- productions suggest there is no (word-level) stress in Korean.
- native perceivers can pick out prominent syllables, though not very confident in their choices.
- perceivers of a stress language give different answers than perceivers of an accent language (and native Koreans), due apparently to misinterpretations of intonational patterns

28) Typological difference between stress & non-stress languages (Beckman, 1986; Tajima, 1999).

Stress: (English)

- > Stress as nested levels of hyperarticulation (de Jong, 1995)
- > Perceptual cues to stress location include large effects of duration, amplitude and vowel quality
- > Though largely cued by F0 as indicating the association of a pitch accent

Non-stress: (Japanese)

- > Lexical specification of F0 fall
- > Perception of prominence dominated by interpretation of F0 pattern
- > Attention modulation not tied to syllables with associated accents

29) Balinese (Barber, 1977; Herman, 1998)

Barber (1977): First:

"There is no strong word-stress in Balinese in ordinary speech, there is only a slight variation in loudness and energy between the syllables of a sentence."

Then (same page later on):

"In words of more than two syllables (not counting suffixes), the penultimate syllable is stressed unless the vowel is e."

Herman, 1998:

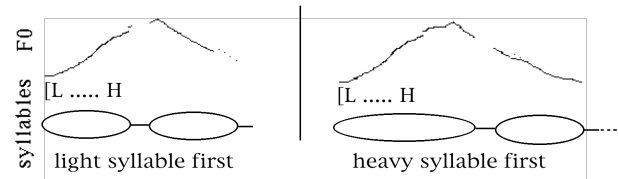
"It is theoretically impossible to prove that some entity does not exist. Therefore, it is impossible to prove that word-level accentuation does not exist in Balinese. However, if word-level accentuation in some form did exist, one might expect to find certain indications of it."

30) Lim & deJong (In Press): How do tones and syllables align?

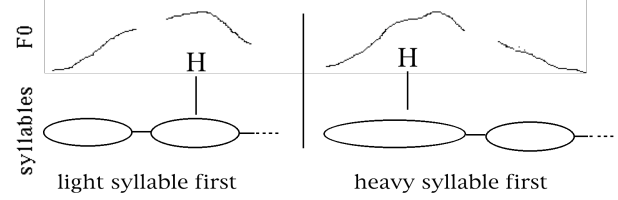
- Accentual phrase gets marked with an initial rise (LH-tone pattern)
- Results indicate stochastically weight-sensitive tonal alignment. Many peaks occur a fixed distance from onset. Some, however, are delayed to the onset of the second syllable. More of the delayed peaks follow light syllables than follow heavy syllables.
- Suggests: Weight sensitivity occurs because typical differences in syllable duration create differences in alignment between the high points of boundary rises and the syllables.

31)

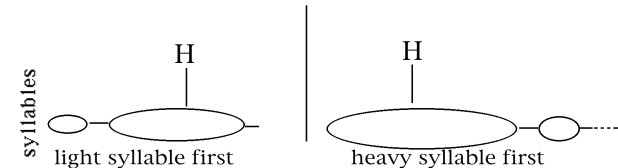
STATE 1: Delimitative, Non-accentual Tones (tones unassociated with syllable level)



STATE 2: Transition, Non-contrastive Accent (tones become differentially associated w/ 1st & 2nd syll.)



STATE 3: Stress Accrual (prominent syllables garner attention)



32) Reminder: patterns observed in Ahn (2000) (#24b, previous page)

- f) most languages are bounded
- g) beginning stress languages usually stress the first syllable, while end stress languages usually stress the second syllable from the end
- h) consonants only count in bounded systems. I.e. when stress falls on a heavy syllable, irrespective of that syllable's location in the word, the heavy syllable always has a long vowel

33) Historical Interpretation.

- stresses are usually bounded; they nearly always fall within one or two syllables from edges, where one would expect the ends of intonational edge-markers.
- rises tend to be more dynamically compact than falls, hence stresses arising from final falls tend to be further from word edge.

Additional patterns:

- 81% of languages in Ahn's survey: Heavy syllable stresses are one syllable closer to word edges than are light syllable stresses.
- Here, long vowels and consonants behave alike because the both take up time.

BUT

- 9% of languages in Ahn's survey: Heavy attracts stress away from syllables closer to the edge.
- Unbounded languages require explicit attraction of stress.
- Stress in these systems always seems to be attracted by long vowels, not by consonants.

(Of course, these cases should be looked at more closely, given results such as Lim's for Korean. Cole and Ahn examined Kasimiri and have garnered durational evidence that the first long vowel in a word is longer, regardless of where it is in the word. This is expected if Kasimiri is **Weight Sensitive Unbounded** and long vowels are heavy.)

34) Summary points

Not all properties are best explained in terms of synchronic functioning, but rather arise due to typical historical development patterns.

- Here, languages differ radically in terms of attentional modulation, apparently due to idiosyncratic differences in historical development.
- Also, some properties of stress systems, such as coda weight sensitivity are likely to be only properties of diachronic dynamics, and are not best explained in terms of contemporary linguistic functioning.

Properties which likely are connected to historical development patterns are listed below.

35) Property #8: Weight Sensitivity.

Results from stressed items' genetic roots in non-stressed items which are 'picked out' due to one of two properties: 1) f0 peaks associated with prosodic edge-marking may contribute to the selection of syllables a fixed distance from the edge of the word. The presence of consonants affects which syllable this ends up being. 2) phonemic vowel length. Such prominence lending effects unequally affect different syllables, hence providing the seeds for development of stress.

36) Property #9: Morphological Marking.

Since stresses may have historical roots in tonal edge-markers of morphological units, stresses may be consistently found in particular locations within morphological units. Positional consistency is functional as well in that it helps listeners parse utterances into contentful units. (See, McQueen et al, 1994; Cutler and Carter, 1987; Cutler, et al, 1997)

37) Property #10: Boundedness Variation.

Differences in boundedness may be due to what the historical seeds for stress were. Reinterpretation of delimitative markers will yield bounded systems, while attraction of stress to phonemic differences in length will often not yield bounded systems.

38) Property #6: Accent Location (again).

Accents may be associated to stressed syllables simply because the syllables were selected by the presence prominence-lending tonal movements. However... more on this below.

39) Summary of Proposals:

- 1) **Hierarchical Nesting:** Due to the scalar nature of stress.
- 2) **Reduced Contrast:** Due to consistent attentional shift off of unstressed material.
- 3) **Domain:** Due to internal consistency of syllabic components making the syllable a viable acoustic object. Also due to onsets as sudden acoustic changes which garner attention.
- 4) **Alternation:** Due either to oscillatory nature of attention modulation or simply the long term local effect of attentional selectivity.
- 5) **Spacing:** Due either to oscillatory nature of attention modulation or a more general efficiency of use in processing time.
- 6) **Accent Location:** Due to historical connections with tones as well as the function of accent in directing attention.
- 7) **Culminativity:** Due to functionality of a one-to-one relationship between attentional and lexical units.
- 8) **Weight Sensitivity:** Due to historical seeds of stress in delimitative tones and vowel quantity.
- 9) **Boundedness:** Also due to historical seeds of stress in delimitative tones.
- 10) **Boundedness Variation:** Due to the existence of two seeds for stress accrual.

40) Some example projects:

- 1) **Cross-linguistic typology.** Need more direct quantitative evidence concerning languages said to be tokens of various stress-system types.
- 2) **Stress and focus.** Need more work comparing and contrasting the phonetic effects of focus and stress. Are they the same? How is focus different in stress and non-stress languages? What is the level at which stress and focus apply?
- 3) **Stress function.** Does stress act like various other parameters which are varied in attention studies?
- 4) **Stress instantiation - culminativity.** To what extent are stressed syllables in a one-to-one correspondance with lexical items in running speech?
- 5) **Stress instantiation - Spacing:** In conversational and monologue style of speaking, what evidence for oscillatory entrainment and under what circumstances?
- 6) ...

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