A phonetic description of speech rhythm across languages, language varieties and language learners

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1. Measuring speech rhythm

Rhythm Ratio (Gibbon & Gut 2001)

$$RR = 100 \sum\nolimits_{k=1}^{m-1} \frac{d_i}{d_j} / (m-1)$$

where $d_i=d_k$ and $d_j=d_{k+1}$ if d_i is smaller than d_j and $d_j=d_k$ and $d_i=_{dk+1}$ if d_i is not smaller than d_j. If the RR equals 100 we have perfect equivalence of adjacent units. The lower the degree of equivalence the lower the RR value. Unlike the Low & Grabe PVI, the RR does not calculate absolute differences in length between adjacent units but computes their ratio. Also unlike the PVI, the RR measurement does not normalise for duration.

2. Measuring speech rhythm of different languages – "stress-timing" vs. "syllable-timing"

2.1 The rhythm of English, Anyi, Ega and Ibibio

	RR	PVI
Anyi	65.8	43.9
Ega	70.1	37.3
Ibibio	66.3	42.4
British English	55.6	61.5

Table 1. Average RR and PVI (syllables) across the 12 sentences in Anyi, Ega, Ibibio and British English.

2.2 Speech rhythm of different varieties of one language: British English and Nigerian English

Speaker	Average PVI (syll)	Average RR (syll)	Average PVI (vowels)	Average RR (vowels)
D (BrEng)	61.5	55.6	51.8	60.7
H (BrEng)	-	-	65.2	54
A (BrEng)	-	-	52.4	67.3
G (NigEng)	63.5	53.7	53.2	59.8
E (NigEng)	49.7	62	62.5	49.2
I (NigEng)	71.1	50.4	64.7	54.2
B (NigEng)	46.2	64.1	41.3	67.3
J (NigEng)	52.1	61.5	48.2	63.2

Table 2. Average pairwise variability index (PVI) and rhythm ratio (RR) for syllables and for vowels for British English and Nigerian English in 10 read sentences. (syllables n=115)

2.3 Non-native speech rhythm: English spoken by German learners

	Average Rhythm Ratio vowels	Average PVI vowels	%V	ÀV*100
German learner	56.6	59.6	47.48	4.3
British English	60.7	51.8	51.2	4.81
British English	67.3	52.4	45.45	3.37

Table 3. Average pairwise variability index (PVI) and rhythm ratio (RR) for vowels for two British English speakers and a German learner of English in 10 read sentences.

3. A multidimensional view of speech rhythm

Several parallel factors that apply to different levels of organisation need to be taken into account
- phrasing
- stress placement
- speech rate
- pitch

Equally, different speech styles need to be analysed.

3.1 Phrasing: British English vs. Nigerian English

speaker	Number of phrases in the read text	Average length of phrase in read text
D (British English)	39	7.7
H (British English)	23	13.3
A (British English)	37	8.3
G (Efik)	43	7.1
E (Ibibio)	43	7
I (Igbo)	44	7.2
B (Edo)	49	6.5
J (Yoruba)	52	5.9

Table 4. Number of phrases produced in the read text by all speakers, the average length of each phrase (in syllables).

3.2 Phrasing: British English vs. German learners of English

	Text 1	Text 2
British native speakers	43 to 48	16 to 21
German learners	38 to 58	18 to 26

Table 5. Range of number of phrases produced in two read texts by the British native speakers and the German learners of English.

3.3 Stress placement

	Text 1	Text 2
British English native speakers	51 accents (31.09%)	78 accents (30.47%)
German learners	46 to 51 accents (28% to 31.1%)	76 to 92 accents (30% to 35.9%)

Table 6. Number of accents produced in two read texts by the British native speakers and the German learners of English.

3.4 Speech rate: British English and Nigerian English

Speaker	Average syllable length (in ms)		Average vowel length (in ms)	
	Short	long	short	Long
D (BrEng)	126	236	72.6	119.3
E (NigEng)	171	274	72.7	116.4
I (NigEng)	159	324	76	140.4
G (NigEng)	141	262	72.3	121.4
B (NigEng)	167	262	77.6	120.5
J (NigEng)	150	245	86	133.1

Table 7. Average syllable length and vowel length (in ms) for one British English and five Nigerian English speakers in the 10 read sentences.

3.5 Pitch

	A	ti	ger	and	a	mouse	were	wal	king	in	a	field
B	L	H	H	L	L	H	L	H	H	L	L	H
G	L	H	H	M	L	LH	L	H	H	L	L	HL
E	L	H	L	L	L	H	L	M	H	L	L	HL
J	L	M	H	L	L	H	L	H	H	L	L	HL
I	L	H	H	M	M	M	L	H	H	L	L	H

	when	they	saw	a	big	lump	of	cheese	ly	ing	on	the	ground
B	H	L	H	L	H	M	L	H	H	H	L	L	HL
G	H	H	M	M	H	L	L	H	L	L	L	L	L
E	L	L	H	M	H	M	L	M	H	M	L	L	HL
J	H	L	M	L	M	M	L	L	H		L	L	ML
I	M	M	L	L	H	M	L	M	H	H	L	L	HL

	be	kind	and	find	some	thing	else	to	eat
B	L	H	L	H	M	M	L	L	H
G	L	H	M	M	L	L	L	L	H
E	L	H	L	H	H	H	L	L	H
J	L	H	L	H	M	L	H	L	H
I	L	H	M	L	H	L	M	L	HL

Table 8. Tones produced in three sentences by all Nigerian English speakers.

	tiger	walking	lying	something	swallow	whatever
B	HH (7), HM (1), LH (1)	HH	HH	MM	MM	HMM
E	HH (1), HL (1), LH (1), HM (1)	MH	HM	HH	MM	LHH
I	HM (5), LH (1), HH (1), MM (1), LM (1)	HH	HH	HL	ML	MHM
G	HH (8), HM (1), LL (1), MH (1)	HH	LL	LL	MH	LHM
J	HH (7), MH (1)	MM		ML	ML	LHH

Table 9. Tonal patterns produced on multisyllabic words by the Nigerian English speakers.

4. Different speech styles

	RR vowels read speech	RR vowels spont. speech	syll/phrase read speech	syll/phrase spont. speech
BrEng 1	60.7	56.4	7.7	6.7
BrEng2	54	58.2	13.3	18.8
BrEng3	67.3	50.7	8.3	7.5
NigEng1	59.8	58.5	7.1	8.9
NigEng2	49.2	47.2	7	6.2
NigEng3	54.2	58	7.2	6.4
NigEng4	63.2	69.6	6.5	4.8
German	56.6	53.9	10.93	7.3

Table 10. Average rhythm ratio (RR) for vowels for each speaker in 10 semi-spontaneous sentences compared to read speech and the average number of syllables per phrase in read speech and free speech.

	read speech		free speech		
	%V	$\ddot{A}V*100$	%V	$\ddot{A}V*100$	n of vowels
BrEng 1	51.2	4.81	41.86	3.83	113/92
BrEng2	45.45	3.37	32.5	2.17	98/150
BrEng3	43.1	4.63	39.6	3.72	84/73

Table 11. Average %V and average $\ddot{A}V*100$ for the British English speakers in semi-spontaneous speech compared to read speech.

5. References

Gibbon, D. & Gut, U. (2001). Measuring Speech Rhythm. Proceedings of Eurospeech 2001, Aalborg, Denmark.

Low, E.-L. & Grabe, E. (1995). Prosodic patterns in Singapore English. Proceedings of the International Congress of Phonetic Sciences, Stockholm, 3, 636-639.