

Classifying Dysarthrias by Speech Rhythm Metrics

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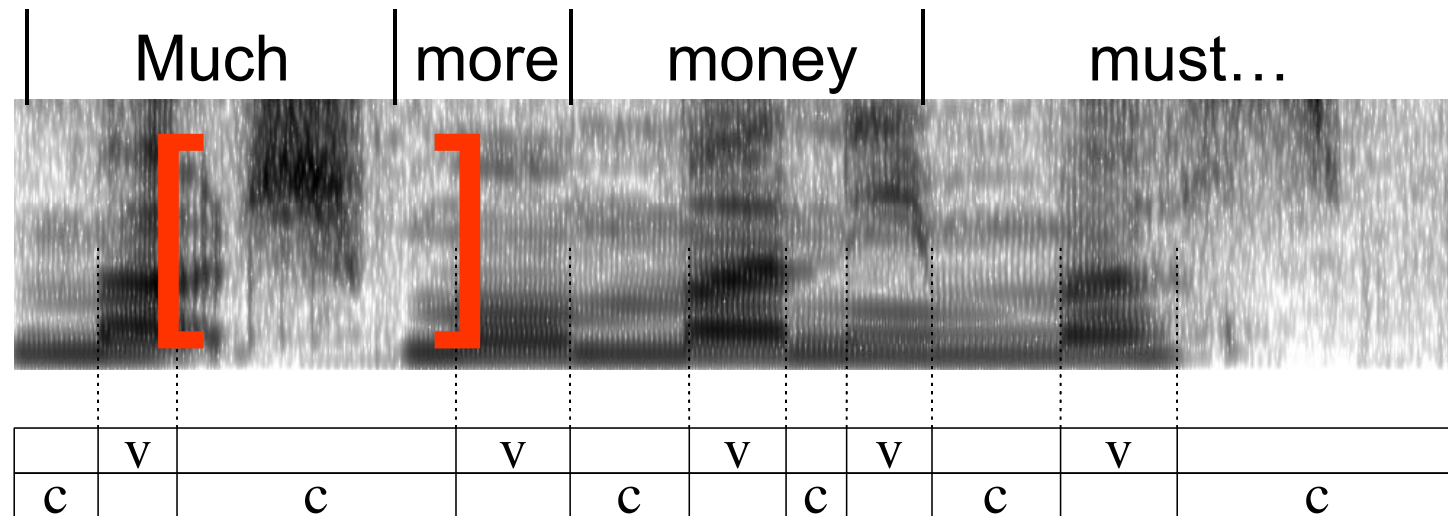
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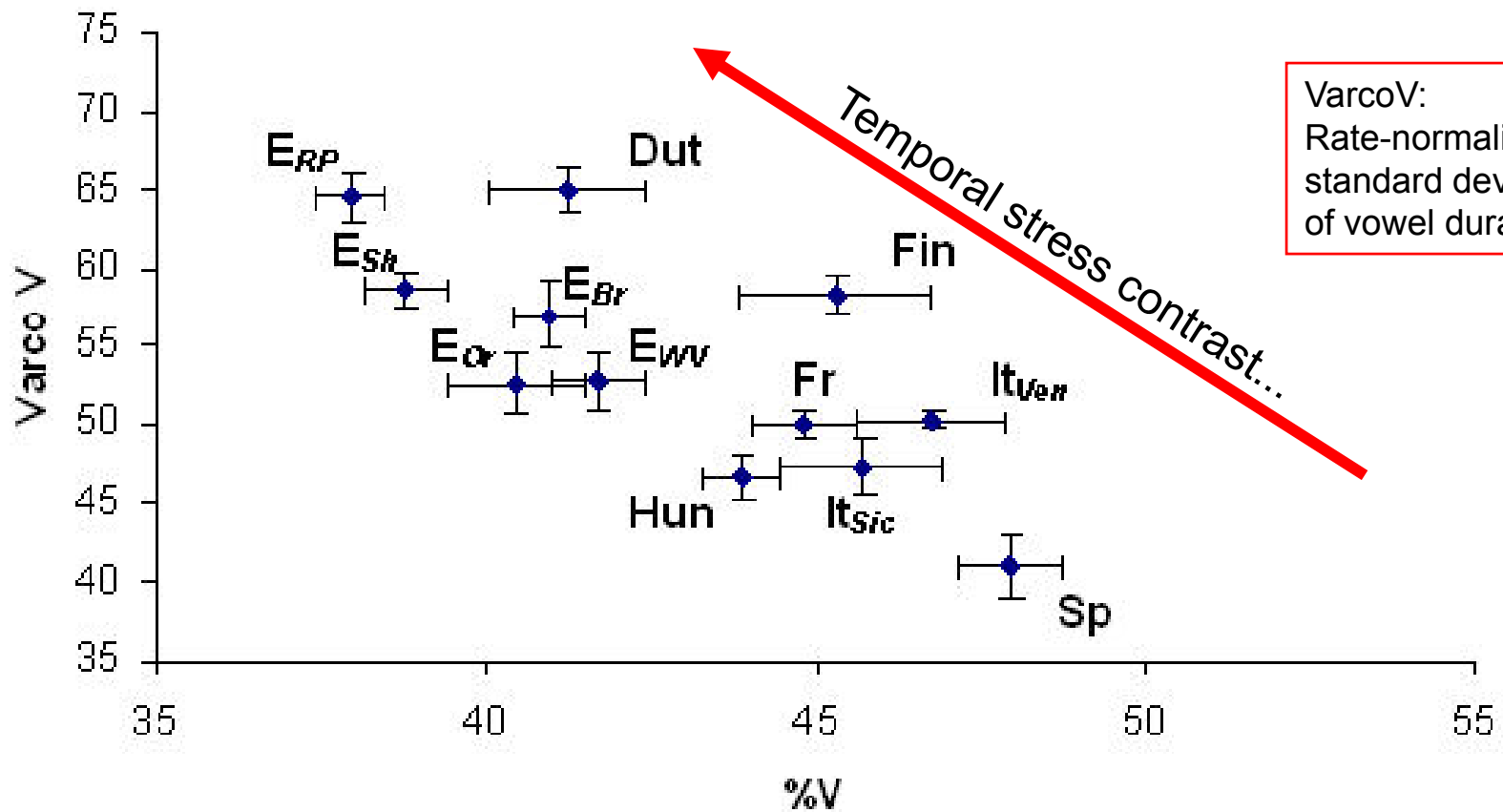
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Acoustic rhythm metrics



- Standard deviation: ΔV , ΔC (Ramus, Nespor & Mehler, 1999)
 - but... inversely related to speech rate.
- Rate-normalised standard deviation: VarcoV, VarcoC. (Dellwo 2006, White & Mattys, 2007a,b)
- Pairwise variability indices: nPVI-V, rPVI-C. (Low, Grabe & Nolan, 2000)
- Compositional balance metric: %V. (Ramus, Nespor & Mehler, 1999)
- Near-syllable durational variation metrics: VarcoVC, nPVI-VC, rPVI-VC.
 - Plus... Articulation rate: syllables/second, excluding pauses.

Acoustic rhythm metrics



VarcoV:
Rate-normalised
standard deviation
of vowel duration

Key	
Dut: Dutch	Fin: Finnish
E: English	Fr: French
Br: Bristolian	Hun: Hungarian
Or: Orcadian	It: Italian
RP: Southern British	Sic: Sicilian
Sh: Shetland	Ven: Venetan
WV: Welsh	Sp: Spanish

White & Mattys (2007a, 2007b):
White, Payne & Mattys (to appear)

Rhythm in dysarthria

- Dysarthric speech is often described as having disordered rhythm (e.g. Darley, Aronson & Brown, 1969):

Excess and equal stress

Reduced stress

Short rushes of speech

Prolonged segments

- Recognizing patterns of rhythmic disturbance may assist in differential diagnosis.

- Research question:

Are dysarthria types discriminated by durational measures of rhythm?

Design of study: Materials and speakers

- Materials:

- Approximant-controlled English sentences:

The supermarket chain shut down because of poor management.

Much more money must be donated to make this department succeed.

In this famous coffee shop they serve the best doughnuts in town.

The chairman decided to pave over the shopping center garden.

The standards committee met this afternoon in an open meeting

- 80 phrases alternating in syllabic strength (Liss et al., 2000)

- Speakers: American English adults, moderate to severe disorder, some level of the cardinal perceptual features:

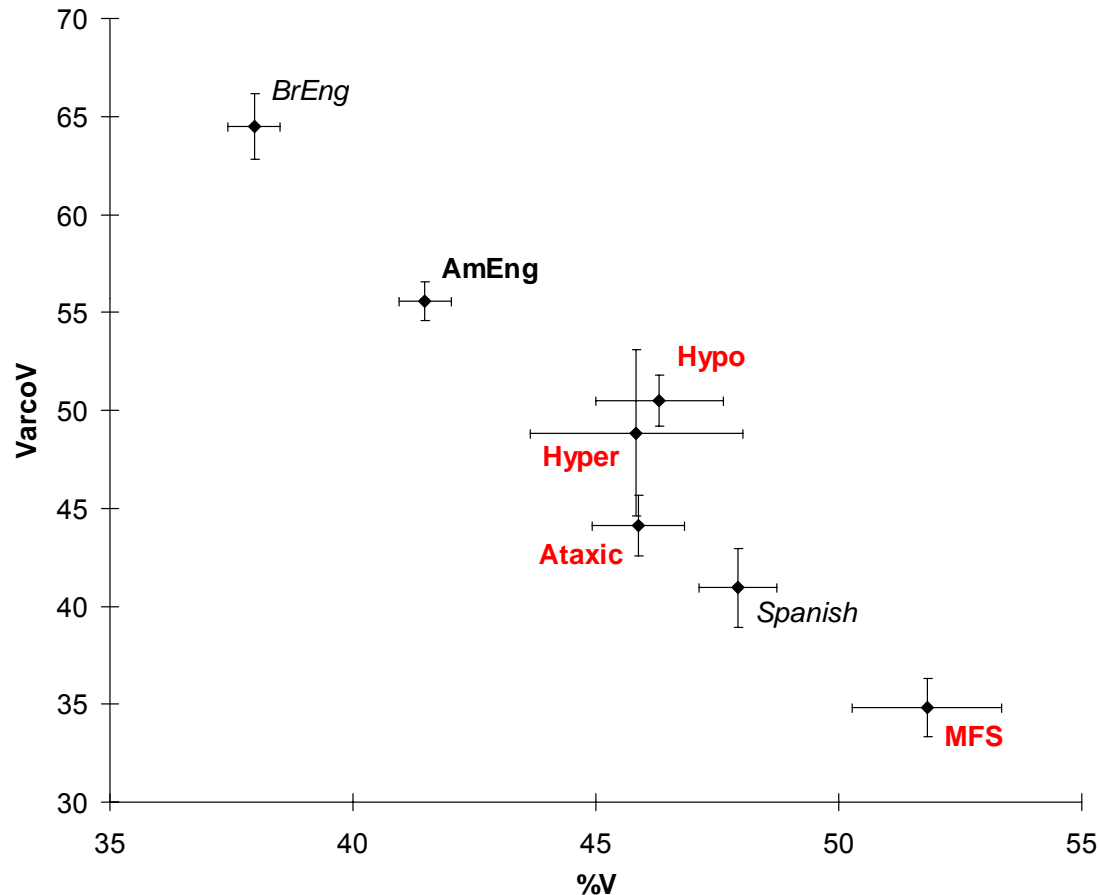
Ataxic	“Scanning” - staccato - speech; irregular articulatory breakdown.	(N=12)
Hypokinetic (Hypo)	Rapid articulation rate; rushes of speech; imprecise articulation; monopitch; reduced loudness.	(N=9)
Hyperkinetic (Hyper)	Irregular pitch and loudness changes; irregular rate changes across syllable.	(N=12)
Mixed flaccid-spastic (MFS)	Prolonged syllables; slow articulation rate; imprecise articulation; strangled voice quality.	(N=10)
Control	American English adult speakers.	(N=12)

Discriminant Function Analysis

- Stepwise DFAs conducted on sentence material to determine which subset of metrics best classifies the speech groups
 - Cross-validation
 - Non-stepwise DFA conducted on 80 phrases
- Various combinations of metrics used:
 - Overall classification accuracy from 79%-88%.
 - Overall best set of metrics: VarcoV, VarcoVC, ΔV , %V, and ΔC .
- Examined further using dysarthria-specific comparisons:
 - Discriminant function analysis, one against the rest.

Mixed flaccid-spastic dysarthria

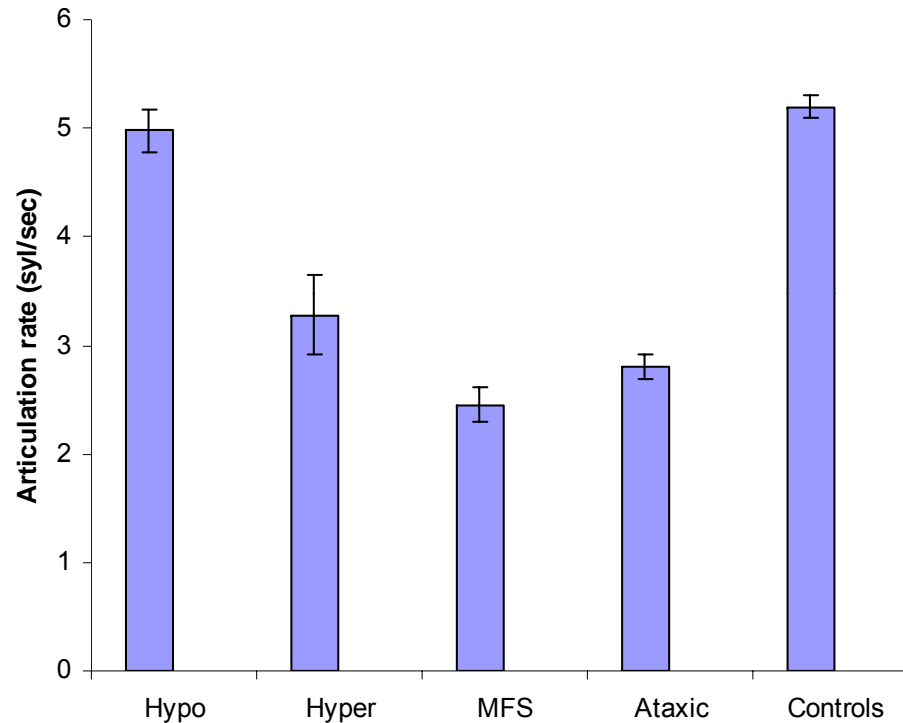
- VarcoV – 82% discrimination.



- Speech slow and prolonged, small breath groups, often syllable-by-syllable:
 - Particular impact on vowels, with long, regular duration.

Hypokinetic dysarthria

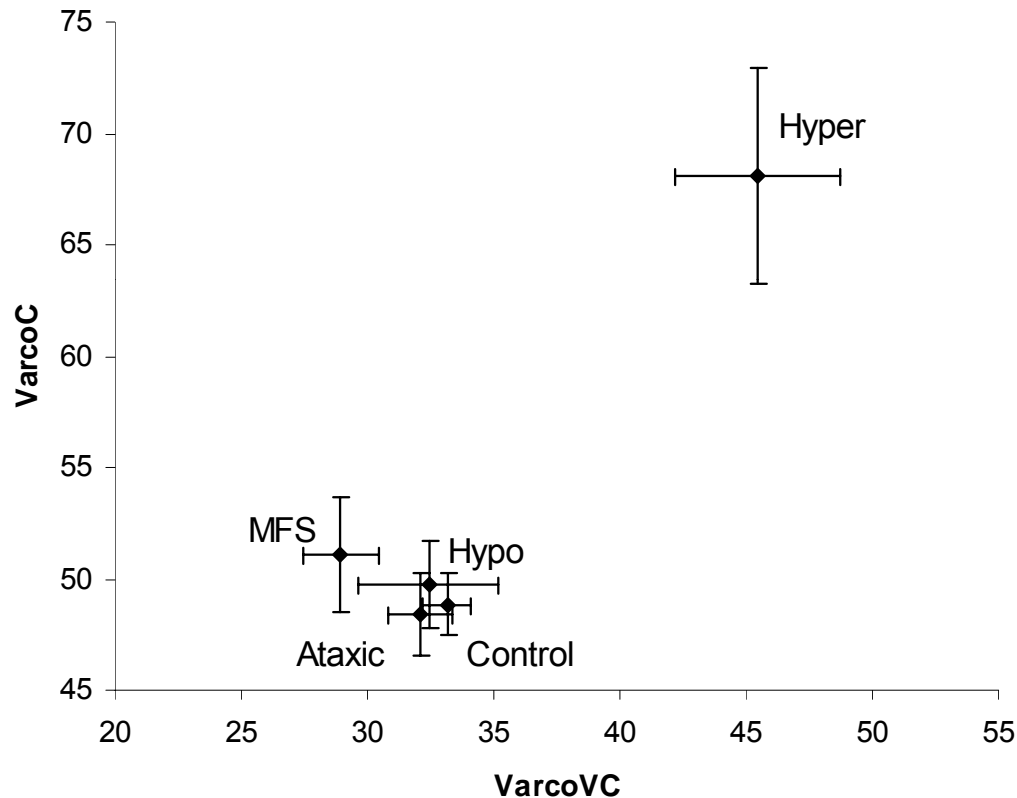
- 100% discrimination from other dysarthrias by articulation rate alone.



- VarcoVC etc. indicate relatively normal rhythm:
 - Motor program essentially intact, but scaled-down spatial domain.
 - Loss of contrast perhaps better captured by measures of loudness and intonational variation.

Hyperkinetic dysarthria

- VarcoC alone provides 85% discrimination from other dysarthrias.

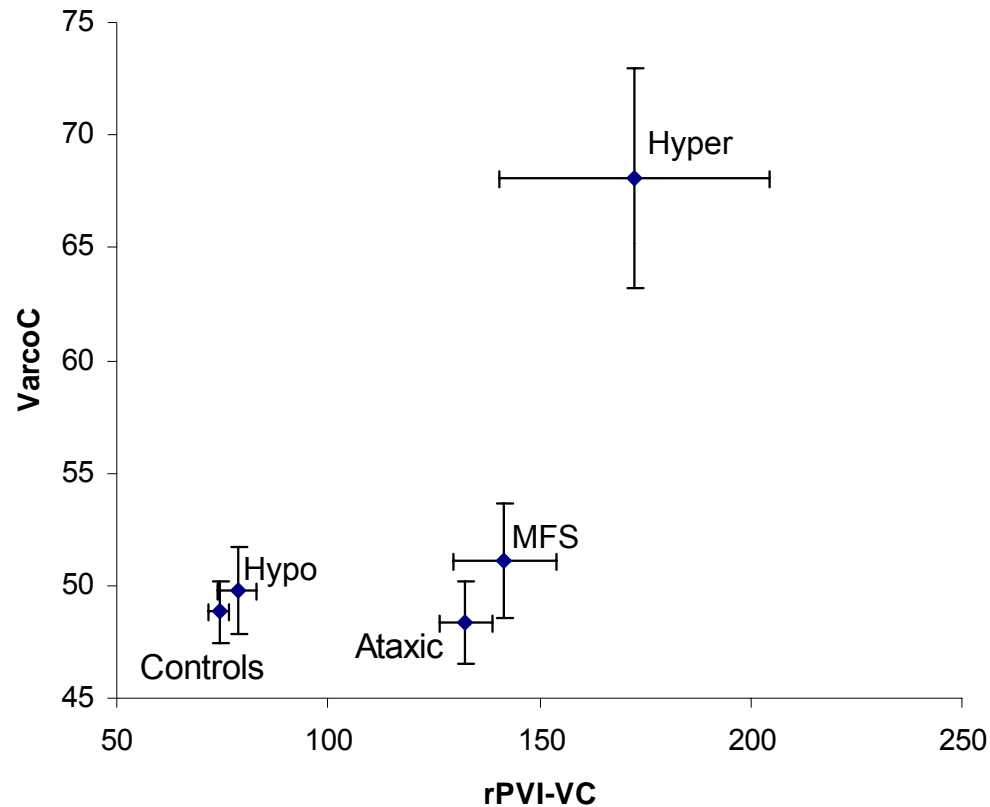


VarcoC/VarcoVC:
Rate-normalized
standard deviation
of consonant/
vowel+consonant
duration

- Characterized by unpredictable intrusive orofacial and body movements:
 - Apparently more impact on consonant duration than on vowels.

Ataxic dysarthria

- Combination of VarcoC, rPVI-VC, nPVI-V provide 85% discrimination from other dysarthrias:



VarcoC/VarcoVC:
Rate-normalized
standard deviation
of consonant/
vowel+consonant
duration

- Less indication of characteristic “equal and even” rhythm than MFS:
 - nPVI-V: Ataxic 55 vs MFS 43.

Summary and Conclusions

- Overall around 80% correct classification within dysarthrias.
- Particular metrics/sets of metrics discriminate specific dysarthrias:
 - Coincide with perceptual features and underlying production constraints.
 - Composite VarcoVC metric discriminatively useful.
- Potential for use of metrics as clinical tool within battery of tests.
 - Particularly useful for tracking change in speech symptoms.
 - Improvement in automated extraction of interval durations required.
- Cross-linguistic differences in nature of deficit?
 - Differential impact on intelligibility?

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