

# EXPLORING NATURAL SPEECH INTONATION OF AN UNDER-RESEARCHED PAPUAN LANGUAGE

Alexander Zahrer, University of Münster

## Introduction

Language documentation often overlooks acoustic data, focusing instead on morphosyntax. Challenges include lack of prosodic research training, time constraints, and poor recording conditions.

We apply contour clustering (Kaland 2021) to explore the intonation of an under-researched Papuan language. The emphasis is on form-driven analysis to minimize assumptions about phonological categories. The results enhance understanding of prosody and may inform further phonological research.

**Muyu** (Trans New Guinea) is spoken by ca. 2,000 people in Western New Guinea. Some features are: rich verb morphology, complex predicates, verb final constituent order (SV/AOV), clause chaining and switch reference.

## Research question

We investigate intonation in complex sentences. Such structures are composed of units with verbs marked for syntactic completion: **Final Verbs** (sentence complete), **Medial Verbs** (sentence ongoing), **Multi Verbs** (continuation within the same predicate).



Prosodic phrasing breaks long sentences into comprehensible chunks. Such intonation units (IUs) are mostly split after verbs. Our study examines how the pitch contours of verb-final IUs correlate with verb type, hypothesizing that:

**HYP1**: Incomplete structures (Medial and Multi Verbs) correlate with rising pitch.

**HYP2**: Complete structures (Final Verbs) correlate with falling pitch.

## Data & Methods

A total of **355 IUs** were segmented from 5 recordings of naturalistic monological speech (3 speakers: 2 male, 1 female). Two cues for setting IU boundaries: (a.) interruptions caused by pauses or final lengthening, (b.) disruptions of pitch such as sudden f0 jumps and pitch reset. IUs without verb at right boundary or that spanned over more than one syntactic unit were removed. Each IU was annotated for verb type it contained:

Verb type	Occurs in	Mean Dur	SD
FINAL VERB	148	0.846	0.352
MEDIAL VERB	115	0.805	0.352
MULTI VERB	92	0.852	0.425
<b>Sum</b>	<b>355 IUs</b>		

Table 1: Verb types distributed over 355 IUs, mean durations (in sec.) of IUs and standard deviation (in sec.) of IUs.

As acoustic data, we **measured f0** for each IU at **20 consecutive points**. Stylization and interpolation helped to mitigate micro-prosodic variation and empty measures due to voiceless segments. In addition, normalization of the data accounted for differences in gender and pitch range of speakers.

We performed an agglomerative **hierarchical clustering algorithm** in R provided by Kaland (2021). The distance matrix contained **EUCLIDIAN DISTANCES** and the algorithm used **COMPLETE LINKAGE**. Hierarchical clustering does not result in a fixed number of clusters but in a dendrogram that can be further investigated for the optimal number of clusters.

Finally, we analyse the correlation between the clusters and verb types. Our tool also calculates **mean pitch contours** which allows a **visual inspection** of the relation.

## Results

We found an optimum of **7 clusters**. IUs and verb types distribute as shown in Table 2.

Cluster	1 (C)	2 (C)	3 (A)	4 (A)	5 (B)	6 (A)	7 (B)
<b>N</b>	68	13	39	101	15	65	24
<b>M se</b>	0.06	0.17	0.1	0.04	0.19	0.05	0.11
<b>FIN</b>	25%	15%	<b>56%</b>	<b>47%</b>	13%	<b>60%</b>	8%
<b>MED</b>	<b>41%</b>	<b>54%</b>	23%	29%	<b>53%</b>	23%	<b>63%</b>
<b>MULTI</b>	34%	31%	21%	25%	33%	17%	29%

Table 2: Contours distributed over clusters: total numbers per cluster (=N) and mean standard error (=M se); verb types per cluster (three lower rows).

Groups of clusters based on pitch movement of mean contours:

A - Falling pitch (clusters 3, 4, 6)

B - Rising pitch (clusters 5, 7)

C - Level pitch (clusters 1, 2)

FINAL VERBS dominate clusters of group A (i.e. falling pitch), while MEDIAL VERBS dominate groups B (i.e. rising pitch) and C (i.e. level pitch). MULTI VERBS are not dominant in any cluster but relatively more present in group B and C. The assignment of IUs to clusters showed a statistically **significant relation between verb type and pitch contour shape** ( $\chi^2(4)=38.11$ ,  $p<.00001$ ).

## Mean pitch contours

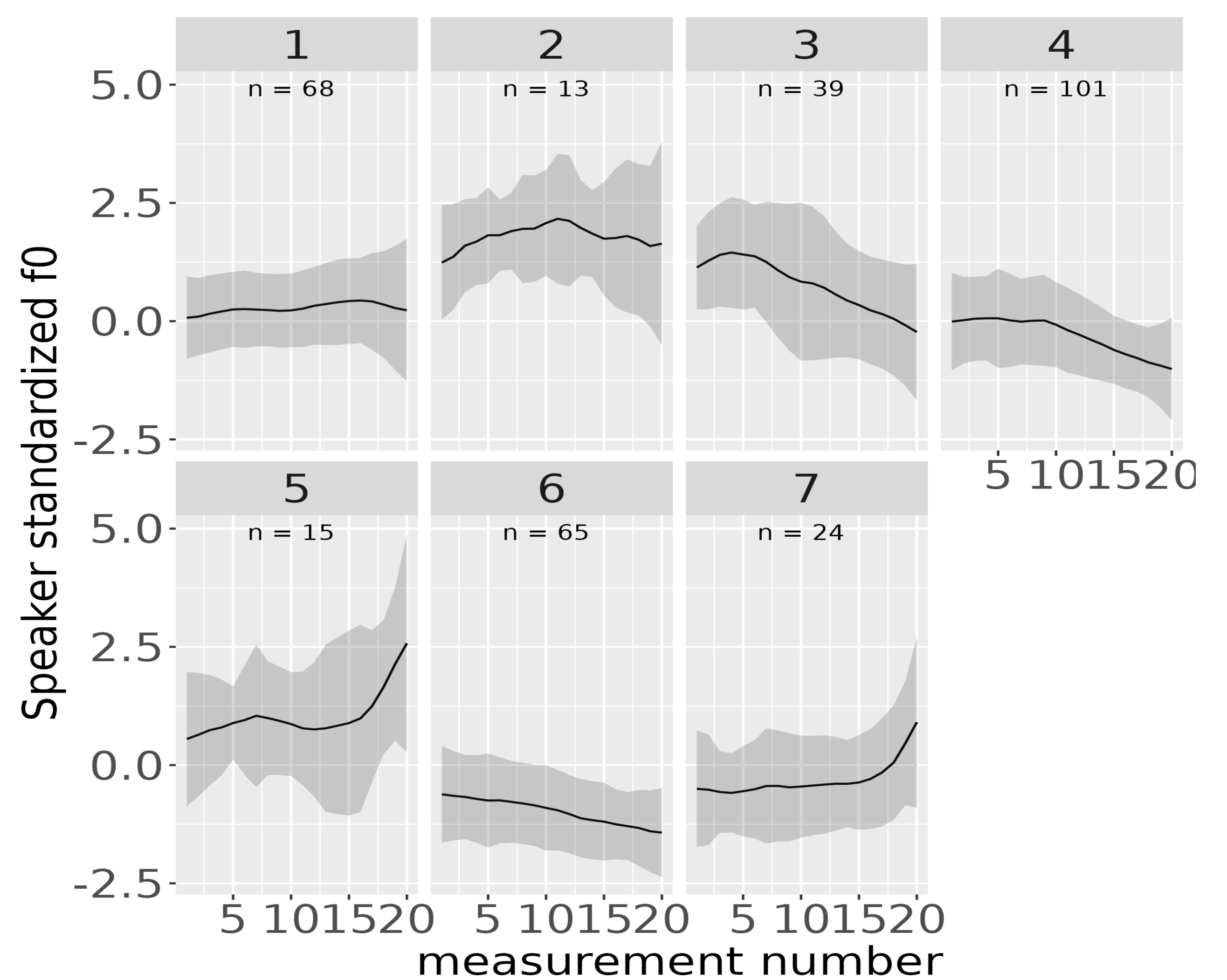


Figure 1: Mean contours for each of the seven clusters.

## Discussion & Conclusion

**Hypotheses confirmed:** Complete structures related with falling pitch (HYP2 ✓). Incomplete structures related with rising pitch (HYP1 ✓) but also level pitch.

**Phonetic Detail:** Initial findings indicate distinct boundary tones linked to verb types; however, deeper investigation into intra-group differences and functional nuances is required. Furthermore, extension to other phonetic variables (duration, intensity) is desirable.

**Contour Clustering as a Tool:** Effectively utilized to study natural speech prosody before defining phonological categories, such as boundary tones.

## Acknowledgements & References

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Zahrer, Alexander. 2023. *A Grammar of Muyu. A Lowland Ok language of Western New Guinea*. PhD thesis, University of Münster.

Kaland, Constantijn. 2021. Contour clustering: A field-data-driven approach for documenting and analysing prototypical f0 contours. *Journal of the IPA*, 1–30.

Himmelman, Nikolaus P. and D. Robert Ladd. 2008. Prosodic description: An introduction for fieldworkers. *Language Documentation & Conservation*, vol. 2, no. 2, 244–274.