COARTICULATION IN TRI-TONAL SEQUENCES IN JOTSOMA ANGAMI LEVEL TONES

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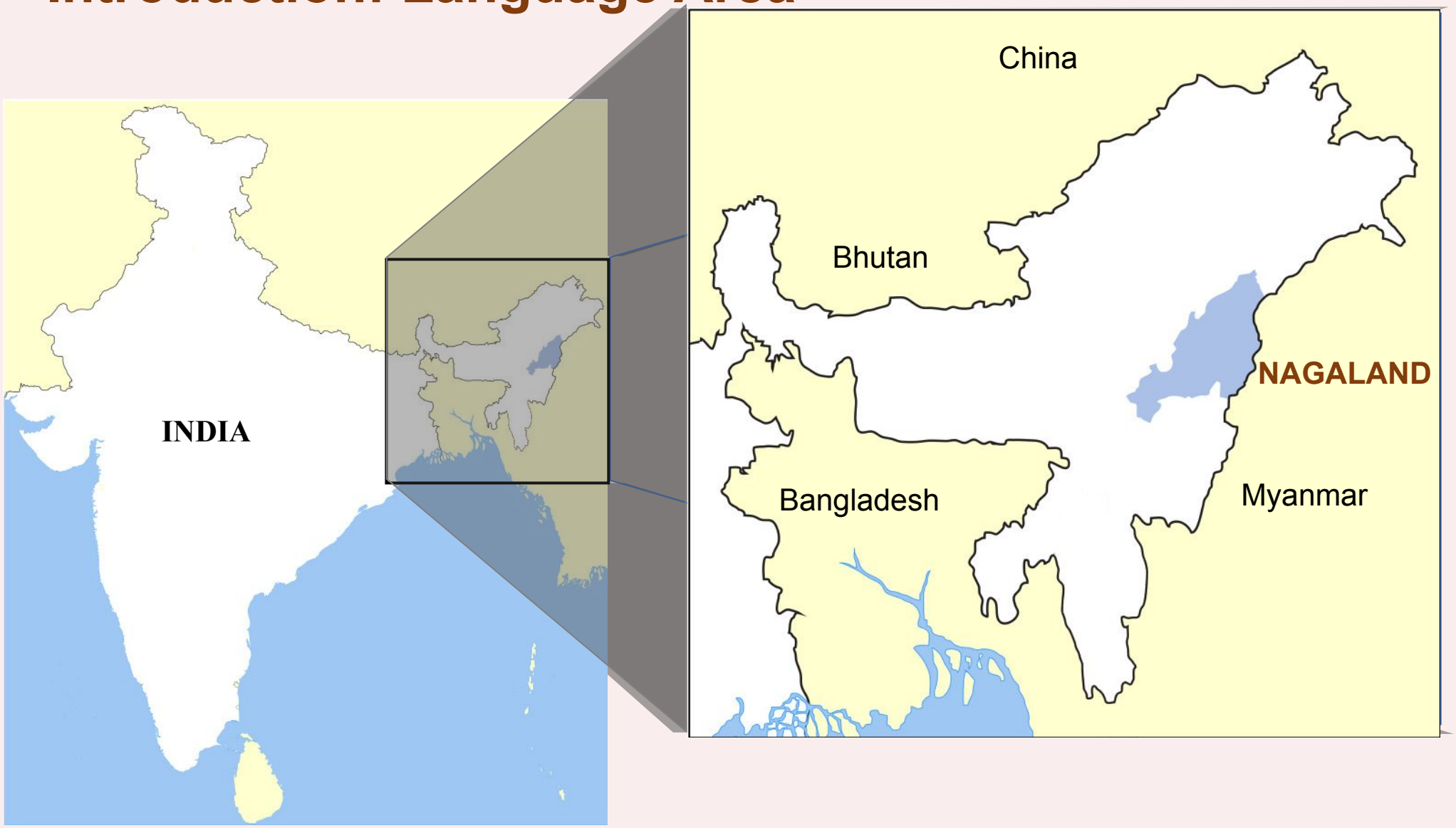
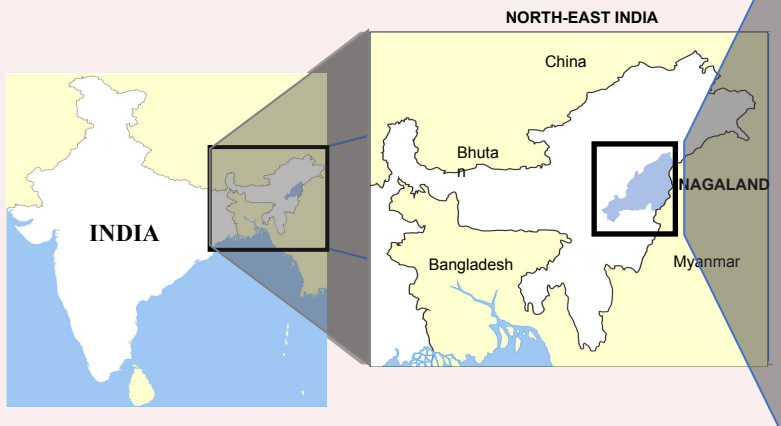
Outline

1. Introduction
2. Literature review
3. Methodology
4. Results
5. Summary

Introduction: Language Area



Introduction: Language Area



NAGALAND

Arunachal Pradesh

ASSAM

MYANMAR (BURMA)

MANIPUR

Mon

Longleng

Mokokchung

Tuensang

Wokha

Shamator

Noklak

Zunheboto

Tseminyü

Niuland

Kiphire

Dimapur

Kohima

Chümoukedima

Phek

Peren

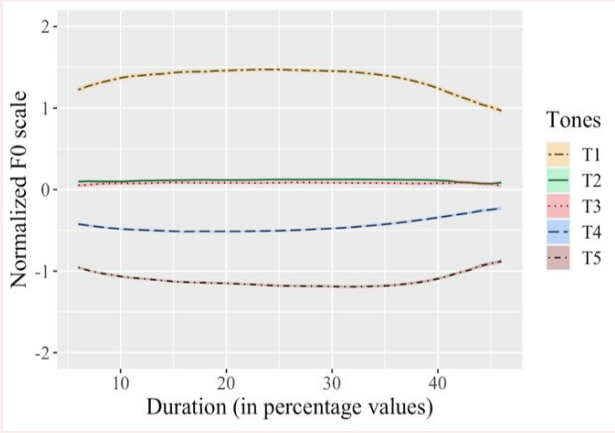
Introduction: Jotsoma Village

Language family	Tibeto-Burman
Place spoken	Western Angami, Kohima Nagaland, NE India
Number of speakers	2458 (2011 census)
Number of tones	4
Types of tones	Register
Number of vowels	6

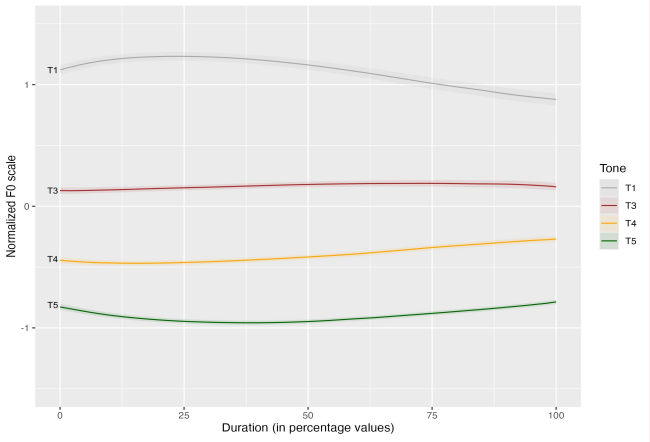
Introduction: Standard Angami Vs Jotsoma Angami

Standard Angami		
Word	Tone	Meaning
/pe/	T1	To incline
	T2	Fat
	T3	Bridge
	T4	Shiver
	T5	Shoot

Jotsoma Angami		
Word	Tone	Meaning
/se/	T1	to use
	T3	three
	T4	to meet
	T5	to snatch



Terhiija, V., & Sarmah, P. (2024). Voice Onset time in Angami. Linguistics of the Tibeto-Burman Area



Normalized F0 contours of Jotsoma Angami tones produced by 16 speakers (8 Males)

Introduction: Standard Angami Vs Jotsoma Angami

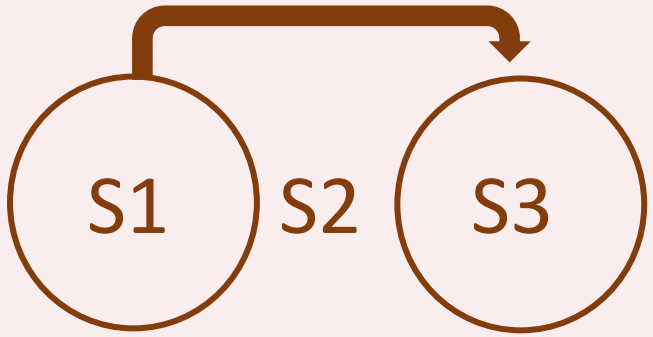
English	Jotsoma	Jotsoma tone	Standard Angami	Standard Angami tone
go + imperative	/vo + lie/	T1T1	/vo + lie/	T1T5
build + imperative	/k^{hw}e + lie/	T1T1	/pf^{h}e + lie/	T1T5
pick + imperative	/t͡ʃə+ lie/	T1T1	/t͡ʃə+ lie/	T1T5
clean + imperative	/me + sa + lie/	T4T1T1	/me + sa + lie/	T4T1T5
drive + imperative	/se + ta + lie/	T1T1T1	/se + ta + lie/	T1T1T5
white + human marker	/ke + kra + ma/	T4T1T1	/ke + kra + mia/	T4T1T5

Introduction: Standard Angami Vs Jotsoma Angami

Jotsoma	Standard Angami	English
/zarsi/	/sʰəko/	maize
/kʰulʰu/	/tsiehusi/	gooseberry
/pi/	/tsie/	mushroom
/ˈsʰətʰoli/	/kerieli/	Frying pan
/tekʷi/	/tepfi/	monkey
/kʰʷe/	/pfʰe/	wait
/po/	/puo/	one
/azo/	/aʒo/	mother

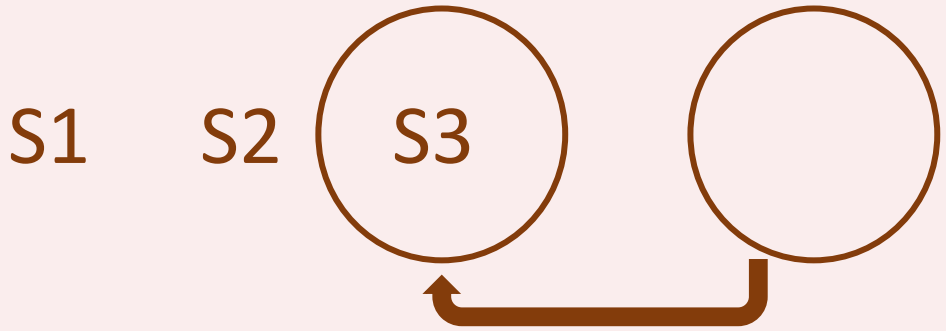
Literature Review: Tonal Co-articulation

Carryover Effect



Literature Review: Tonal Co-articulation

Anticipatory Effect

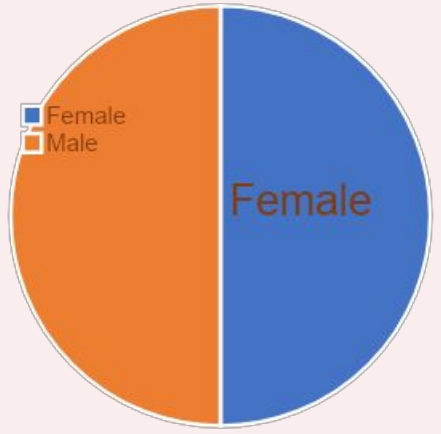


Literature Review: Tonal Co-articulation

Author & year	Language	Coarticulatory effects
Xu (1994) Wong (2006)	Mandarin Cantonese	Carryover Assimilation Anticipatory Dissimilation
Gandour et al. (1994) Sarmah et al. (2015)	Thai Mizo	Anticipatory effects dissimilate and assimilate; Carryover effects assimilate
Zhang & Liu (2011) Chang et al. (2012)	Tianjin Chinese Malaysian Hokkien	Dissimilating carryover effects
Terhiija et al. (2023)	Standard Angami	Dissimilation on higher tones Assimilation on lower tones

Data and Methodology

- Data recorded in April 2024 & April 2025.
- 64 distinct meaningful trisyllable sequences: $CV_1.CV_2.CV_3$, four cases of $V_1C.CV_2.CV_3$.
- Total 2688 trisyllable tokens were analyzed for this study.



Distribution of speakers (n=14)
Mean age: 33.1 (SD=3.3)

Sentence	Carrier	Isolation
po *mu po pe* vor (T1-T5-T5)	a *mu po pe* puba (T1-T5-T5)	*mu po pe* (T1-T5-T5)
s/he tragopan one shoot bring	I tragopan one shoot said	tragopan one shoot
s/he shot and brought one tragopan	I said shot one tragopan	Shot one tragopan

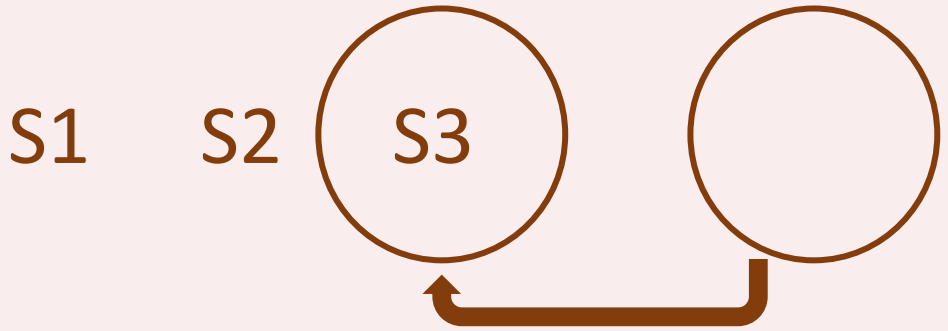
Data and Methodology

- Extract F0 from $V_1.CV_2.CV_3$
- Z-score normalization (Rose,1987)
- gam(F0 ~ Tone_S1 + Tone_S3+ s(Time, by = interaction(Tone_S1 , Tone_S3), k = 30))
- Using the emmeans R package

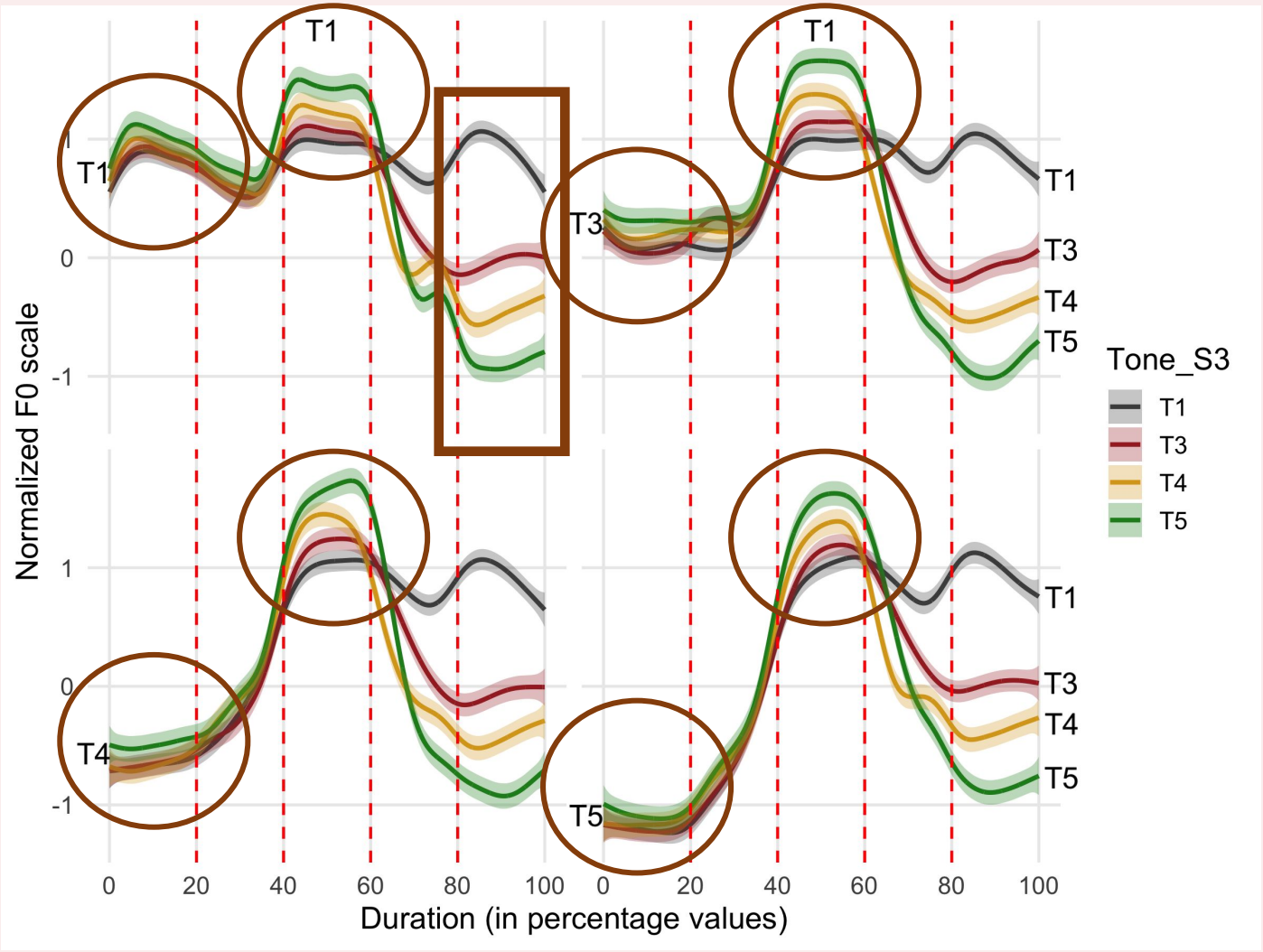
  means<-emmeans (gam-model,pairwise~Tone_S3,adjust="Bonferroni")

Tonal Coarticulation: Anticipatory Effect

Result : Anticipatory effect



Anticipatory effect on T1



- The lower the following tone the higher is the preceding tone
- Dissimilatory effect

Statistical Result: Anticipatory effect on T1

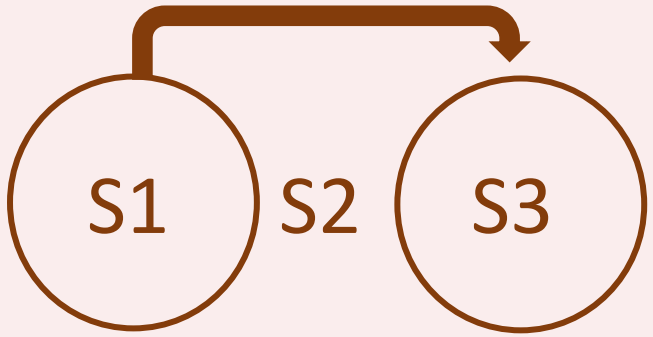
T1T1(X)	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	0.9	0.06	14.6	<.0001 ***
Tone_S3T3	0.1	0.05	2.3	0.01 *
Tone_S3T4	0.2	0.05	4.08	<.0001 ***
Tone_S3T5	0.5	0.05	8.9	<.0001 ***

T3T1(X)	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	0.9	0.06	14.7	<.0001 ***
Tone_S3T3	0.1	0.05	2.6	0.009 **
Tone_S3T4	0.3	0.05	6.1	<.0001 ***
Tone_S3T5	0.5	0.05	10.8	<.0001 ***

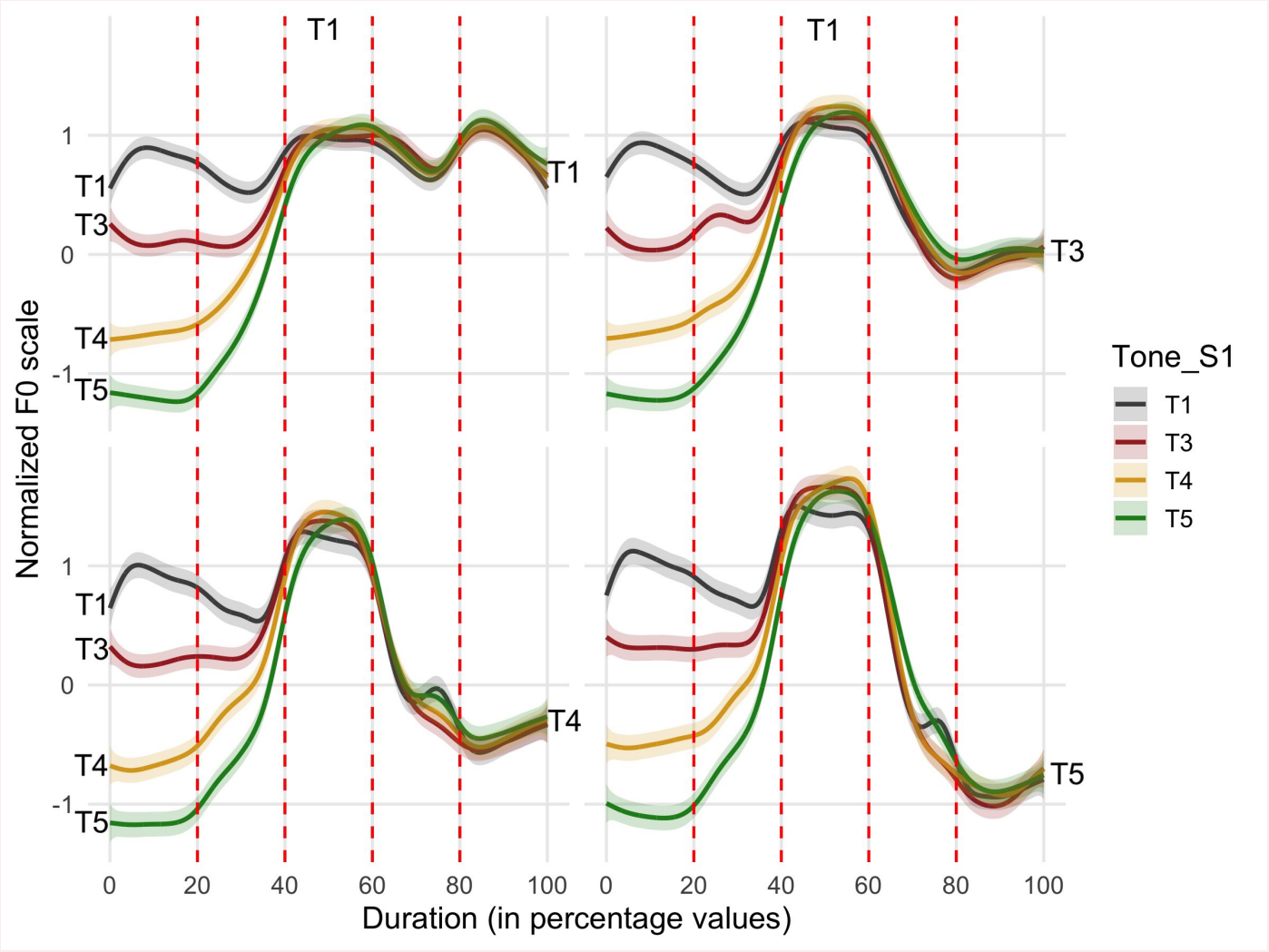
T4T1(X)	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	0.9	0.05	16.8	<.0001 ***
Tone_S3T3	0.1	0.05	2.9	0.003 **
Tone_S3T4	0.3	0.05	6.02	<.0001 ***
Tone_S3T5	0.6	0.05	10.8	<.0001 ***

T5T1(X)	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	0.9	0.07	13.1	<.0001 ***
Tone_S3T3	0.07	0.05	1.4	0.1
Tone_S3T4	0.2	0.05	4.3	<.0001 ***
Tone_S3T5	0.5	0.05	9.4	<.0001 ***

Tonal Coarticulation: Carryover Effect



Carryover effect on T1



- T1 & T4 gives dissimilatory effect
- T3 & T5 gives assimilatory effect

Statistical Result: Carryover effect on T1

(X)T1T1	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	0.9	0.1	9.1	<.0001 ***
Tone_S1T3	0.02	0.04	0.5	0.5
Tone_S1T4	0.02	0.04	0.4	0.6
Tone_S1T5	-0.01	0.04	-0.3	0.7

(X)T1T3	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	1.08	0.07	14.4	<.0001 ***
Tone_S1T3	0.02	0.05	0.5	0.5
Tone_S1T4	0.08	0.05	1.5	0.1
Tone_S1T5	-0.05	0.05	-1.1	0.2

(X)T1T4	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	1.1	0.05	20.07	<.0001 ***
Tone_S1T3	0.1	0.05	1.9	0.04 *
Tone_S1T4	0.1	0.05	2.3	0.02 *
Tone_S1T5	-0.009	0.05	-0.1	0.8

(X)T1T5	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	1.4	0.06	22.9	<.0001 ***
Tone_S1T3	0.08	0.05	1.5	0.1
Tone_S1T4	0.1	0.05	2.7	0.005 **
Tone_S1T5	0.005	0.05	0.09	0.9

Summary

- The anticipatory effect is more prominent than the carryover effect
- The assimilatory or dissimilatory anticipatory effect of T1, T4 and T5 on S2 is statistically significant
- T1 and T5 exert the most effect
- Non-adjacent tone also contributes to the effect

References

- [R. Burling, “(The Tibeto-Burman languages of Northeastern India,” *The Sino-Tibetan Lan- guages*, vol. 3, pp. 169–191, 2003.
- M. J. W. Yip, *Tone*. Cambridge University Press, 2002.
- J. Gandour, S. Potisuk, and S. Dechongkit, “Tonal coarticulation in Thai,” *Journal of Phonetics*, vol. 22, no. 4, pp. 477–492, 1994.
- Y.Xu,“AsymmetryincontextualtonalvariationinMandarin,”*AdvancesinthestudyofChinese language processing*, vol. 1, pp. 383–396, 1994.
- Y. W. Wong, “Contextual tonal variations and pitch targets in Cantonese,” in *Proceedings of speech prosody*. Citeseer, 2006, pp. 317–320.
- P. Sarmah, L. Dihingia, and W. Lalhminghlui, “Contextual variation of tones in Mizo,” in *Inter- speech 2015*, 2015, pp. 983–986.
- S. Chen, C. Wiltshire, B. Li *et al.*, “An updated typology of tonal coarticulation properties,” *Taiwan Journal of Linguistics*, vol. 16, no. 2, pp. 79–114, 2018.
- V. Terhiija, Z. I. Gwirie, and P. Sarmah, “Tonal coarticulation in Angami level tones,” in *Proc. The Second International Conference on Tone and Intonation*, 2023, pp. 44–48.
- P. Boersma, “Praat, a system for doing phonetics by computer,” *Glot. Int.*, vol. 5, no. 9, pp. 341–345, 2001.
- H. Wickham, *ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag New York, 2016. [Online]. Available: https://ggplot2.tidyverse.org
- S. Wood, *Generalized Additive Models: An Introduction with R*, 2nd ed. Chapman and Hall/CRC, 2017.
- J. J. Ohala, “How is pitch lowered?” *The Journal of the Acoustical Society of America*, vol. 52, no. 1A Supplement, pp. 124–124, 1972.
- D.Erickson,T.Baer,andK.S.Harris,“Theroleofthestrapmusclesinpitchlowering,”*Haskins Laboratories Status Report on Speech Research SR-70*, pp. 275–284, 1982.

Thank You