

# Voice quality of coarticulated Mandarin tones

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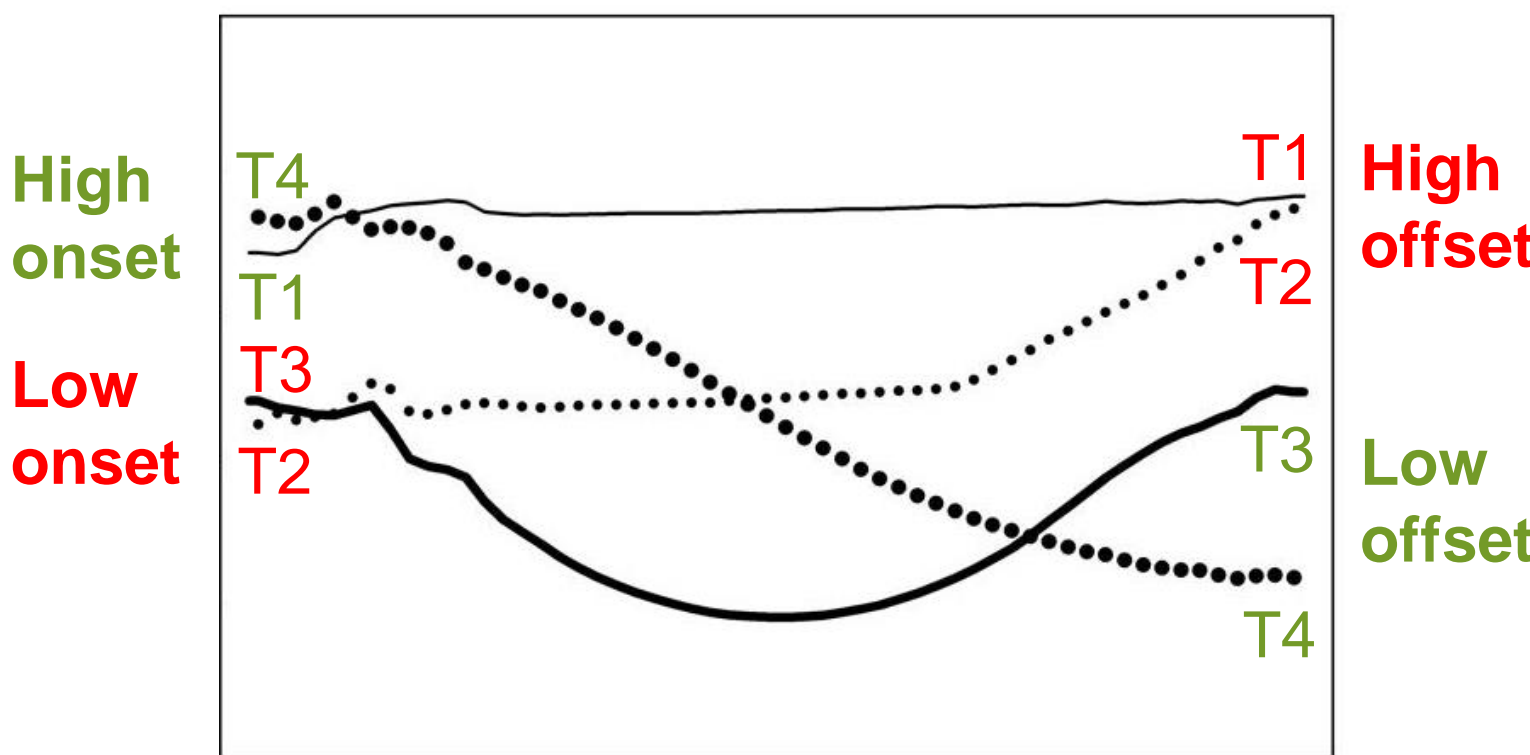
## INTRODUCTION

- Tonal coarticulation often induces changes in F0<sup>1,7</sup> and voice quality<sup>3</sup>.

- In Mandarin, coarticulation has both anticipatory and carry-over effects on F0<sup>6,7</sup>:

- Lowering of F0 when **preceding** tone has **low offset**;
- Raising of F0 when **following** tone has **low onset**.

Resynthesized F0 contour of Mandarin four tones<sup>4</sup>



Low Offset High Onset		High Offset Low Onset	
T3 (21[4]), T4 (51)	X	T1 (55), T2 (35)	X
T1 (55), T4 (51)	↓ F0 lowering environments	T2 (35), T3 (21[4])	↓ F0 raising environments
T3-X-T1 T3-X-T4		T1-X-T2 T1-X-T3	
T4-X-T1 T4-X-T4		T2-X-T2 T2-X-T3	

- In Mandarin, voice quality covaries with F0:

- Creaky voice is associated with low F0<sup>2,5</sup>;
- Low F0 is used by listeners for citation tone identification<sup>4</sup>.

- Research question: How will F0 raising and lowering due to Mandarin tonal coarticulation affect voice quality?**

- Hypotheses:**

- **Lowering of F0 → increase in creakiness (more constricted);**
- **Raising of F0 → decrease in creakiness (more modal).**

## METHODS

- Audio & EGG recordings of tritone sequences

- Target stimuli: trisyllabic Mandarin compounds; each of the four Mandarin tones is flanked by varying Tones 1-4, for a full range of contextual variation of 4\*4\*4=64 combinations

收割机	ʂou1	<b>kr</b> 1	tai1	'Harvester'
齐白石	tɕʰi2	<b>pai</b> 2	ʂi2	'Baishi Qi'
老古董	lau3	<b>ku</b> 3	ton3	'Old-fashioned'
放大镜	fan4	<b>ta</b> 4	tein4	'Magnifier'

- Stimuli are embedded in a carrier sentence:

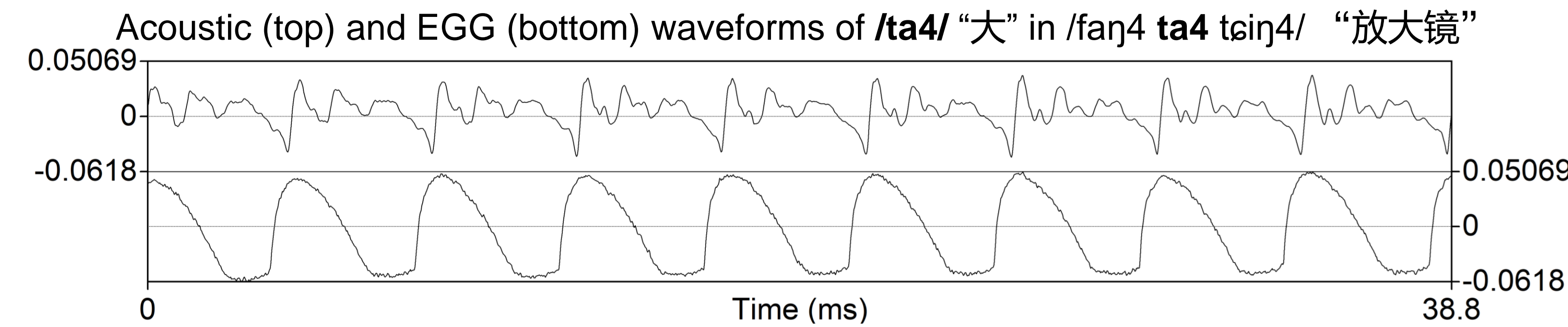
- *Wǒ jiāo nǐ TARGET zěn me shuō* 'I teach you TARGET how to say.'

- Participants: 14 native Mandarin speakers (7M)

- Each participant uttered two repetitions of the 64 sentences = 128 tokens per speaker

- F0 and Contact Quotient (measured from the EGG signal) obtained from VoiceSauce and EggWorks
  - z-scored and time-normalized each measure's values over nine equal intervals (9 points/syllable)

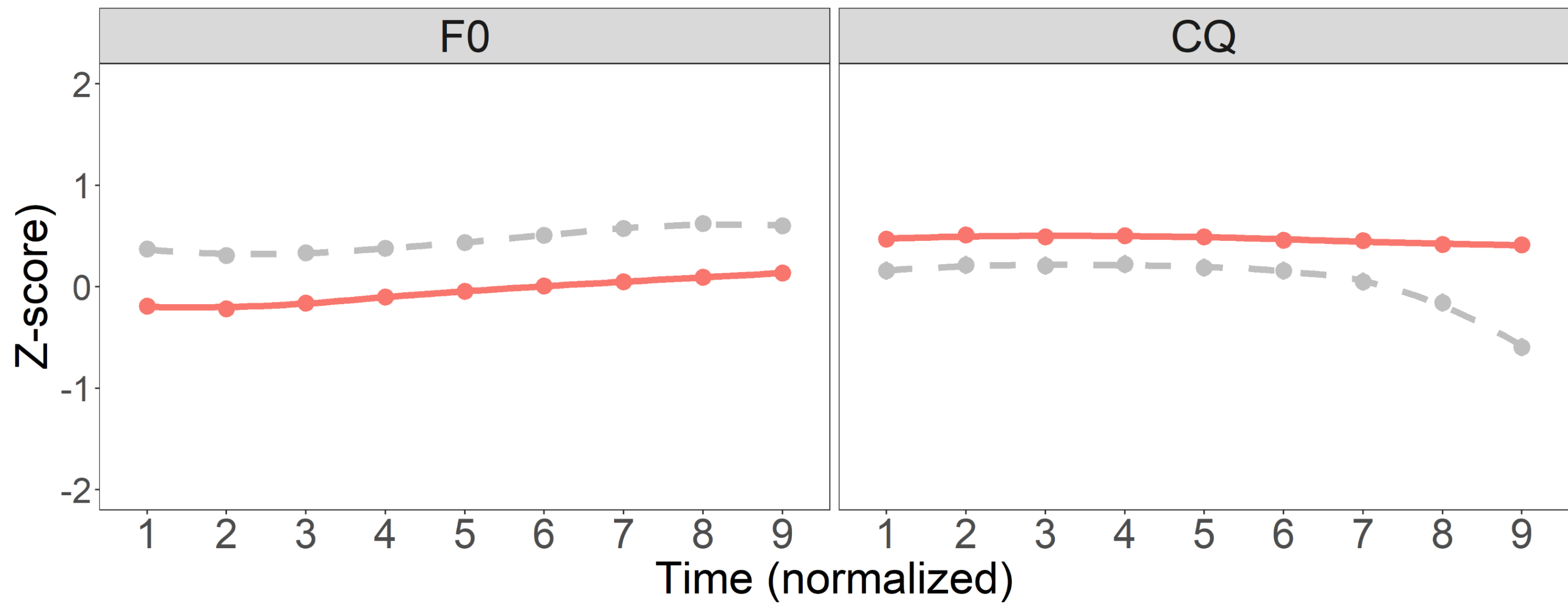
- Higher values of CQ = more constricted → creakier



## SAMPLE RESULTS FOR COARTICULATED TONES

- - - dashed: grand mean contour

Tone 1 (55) in 3- 1 -1 sequences



**Lowering Environment:**

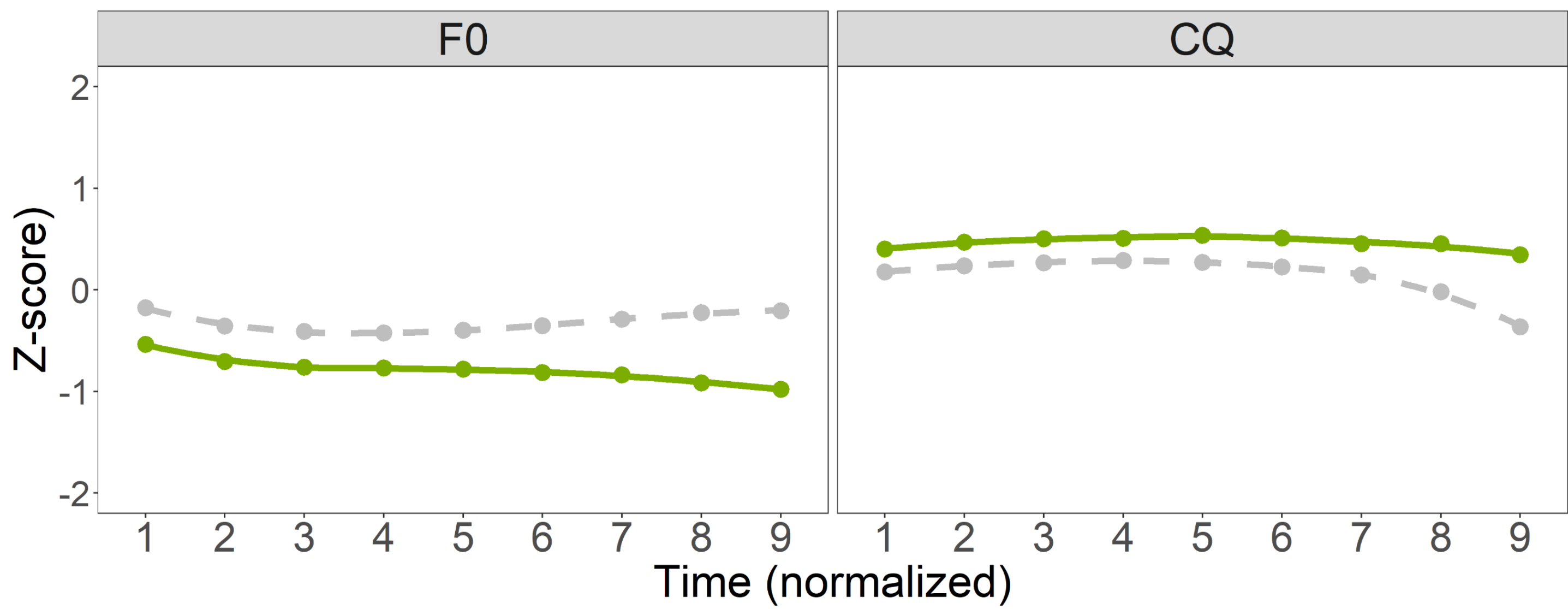
Low offset – T1 – High onset

**Results:**

F0 of Tone 1 ↓

CQ of Tone 1 ↑

Tone 2 (35) in 4- 2 -4 sequences



**Lowering Environment:**

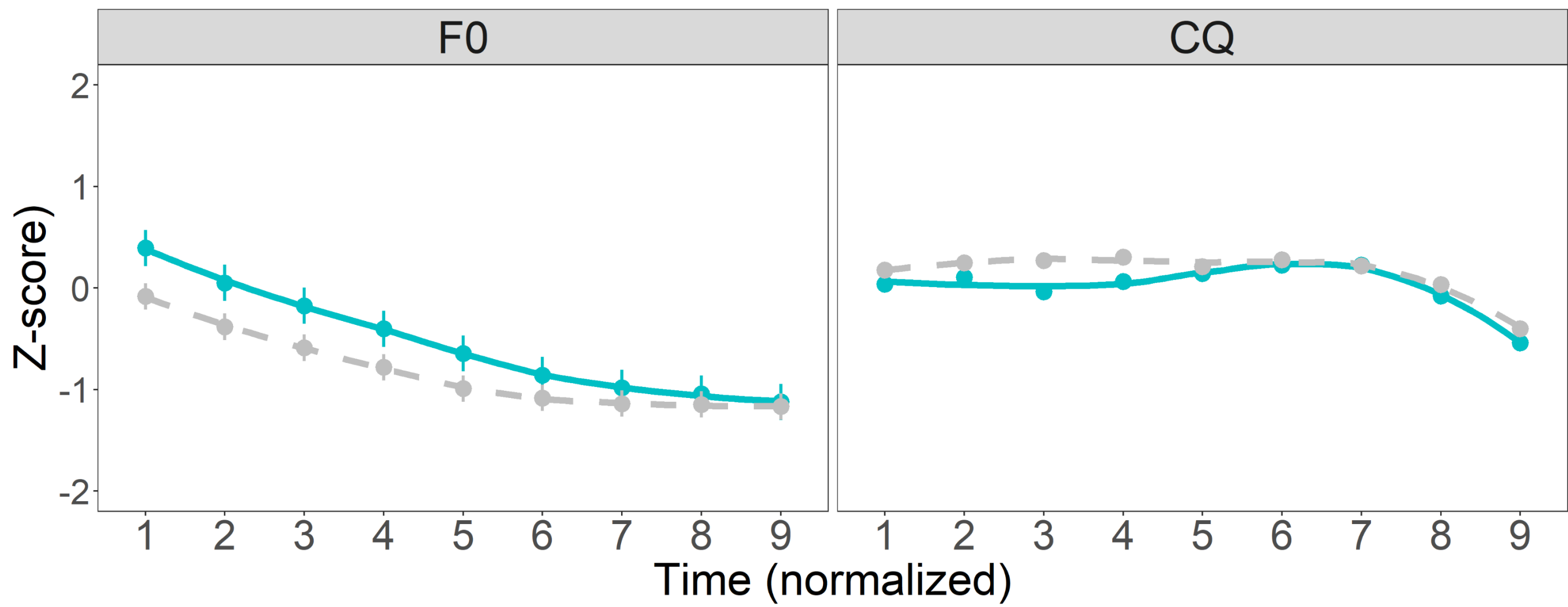
Low offset – T2 – High onset

**Results:**

F0 of Tone 2 ↓

CQ of Tone 2 ↑

Tone 3 (21[4]) in 2- 3 -2 sequences



**Raising Environment:**

High offset – T3 – Low onset

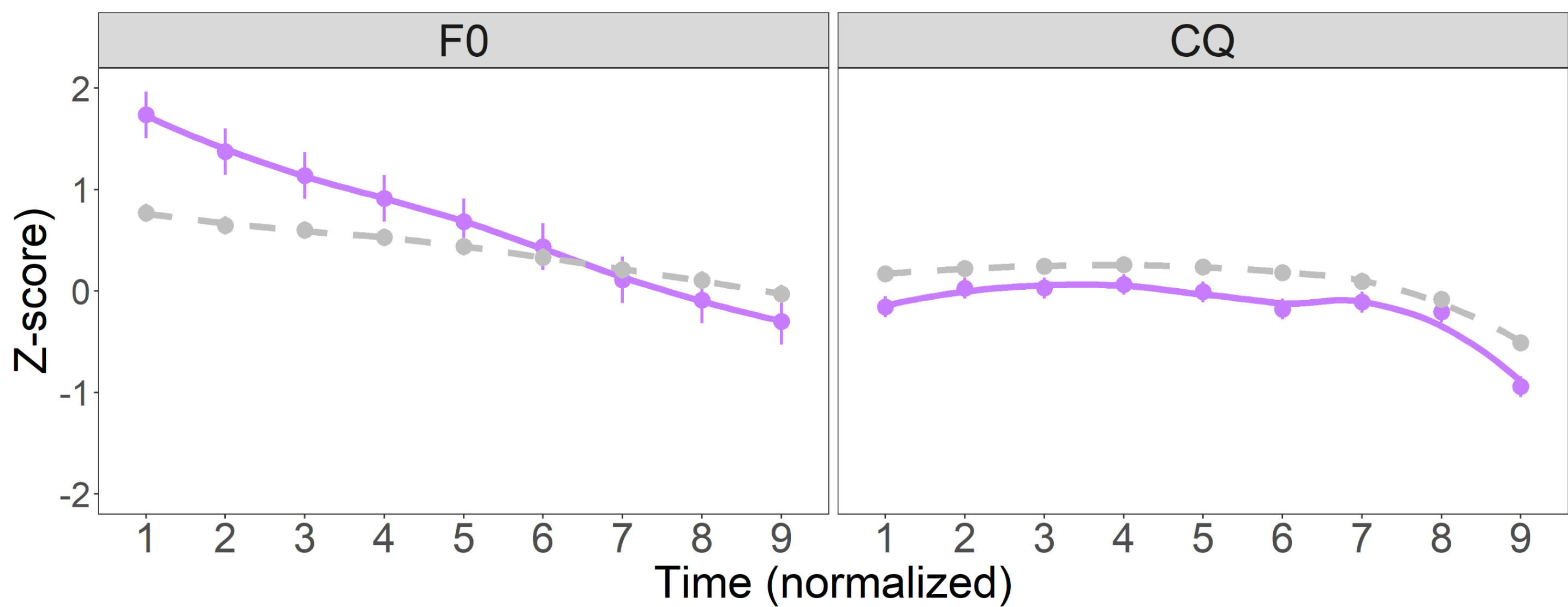
**Results:**

F0 of Tone 3 ↑

CQ of Tone 3 ↓

(excluding x-3-3 sequences)

Tone 4 (51) in 1- 4 -2 sequences



**Raising Environment:**

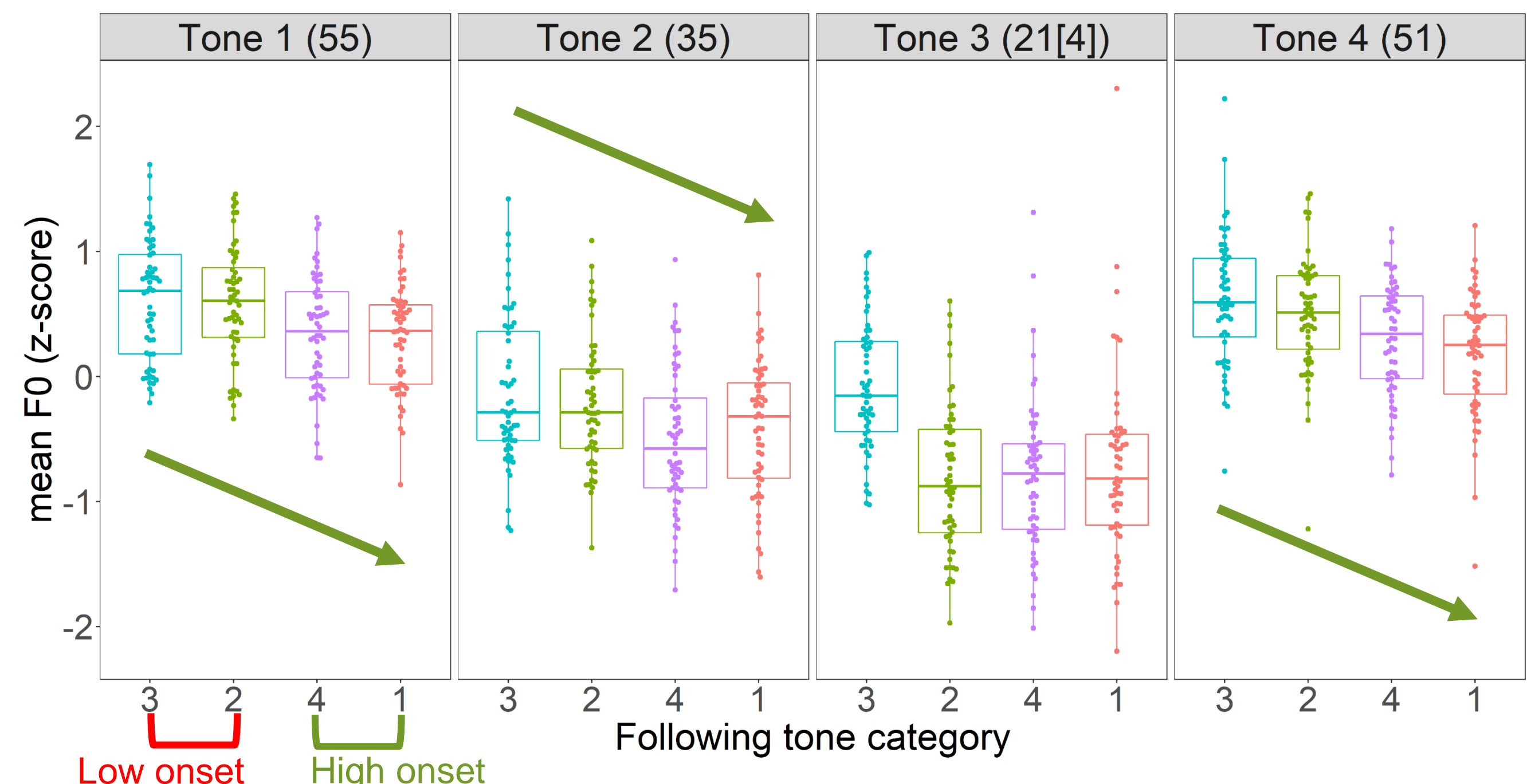
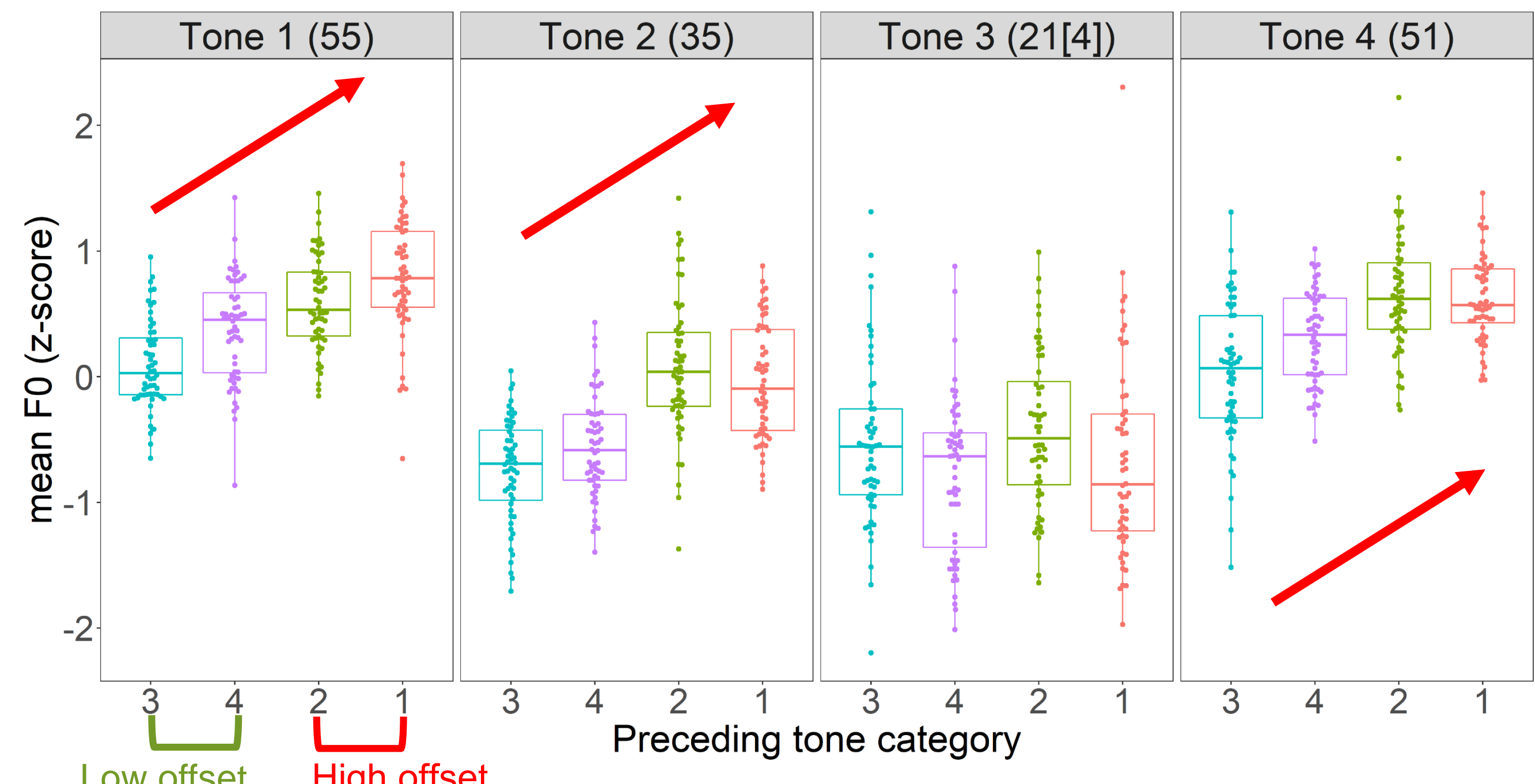
High offset – T4 – Low onset

**Results:**

F0 of Tone 4 ↑

CQ of Tone 4 ↓

## CARRYOVER & ANTICIPATORY EFFECTS



## DISCUSSION & CONCLUSION

- In a tritone sequence, preceding tones have a different effect than following tones: assimilatory or dissimilatory, which largely accord with Xu (1997).

- Every tone can undergo F0 raising or lowering, depending on the tonal environment.

- Raising of F0 results in a more modal voice quality;

- Lowering of F0 results in a more constricted voice quality.

- Voice quality is dependent on F0 in Mandarin, more than on tone (Kuang, 2017).

## DISCUSSION & CONCLUSION

- [1] Brunelle, M. (2009). Northern and Southern Vietnamese tone coarticulation: A comparative case study. *Journal of Southeast Asian Linguistics*, 1(1), 49-62.
- [2] Chai, Y. (2019). The source of creak in Mandarin utterances. 19<sup>th</sup> ICPHS, Melbourne, Australia 2019 (pp. 1858-1862).
- [3] DiCanio, C. T. (2012). Coarticulation between tone and glottal consonants in Itunyoso Trique. *Journal of Phonetics*, 40(1), 162-176.
- [4] Huang, Y. (2019). The role of creaky voice attributes in Mandarin tonal perception. 19<sup>th</sup> ICPHS, Melbourne, Australia 2019 (pp. 1465-1469).
- [5] Kuang, J. (2017). Covariation between voice quality and pitch: Revisiting the case of Mandarin creaky voice. *The Journal of the Acoustical Society of America*, 142(3), 1693-1706.
- [6] Sun, Y. & Shih, Chilin (2019). Anticipatory tonal coarticulation: How, when and why it occurs. 19<sup>th</sup> ICPHS, Melbourne, Australia 2019 (pp. 196-200).
- [7] Xu, Y. (1997). Contextual tonal variations in Mandarin. *Journal of Phonetics*, 25(1), 61-83.