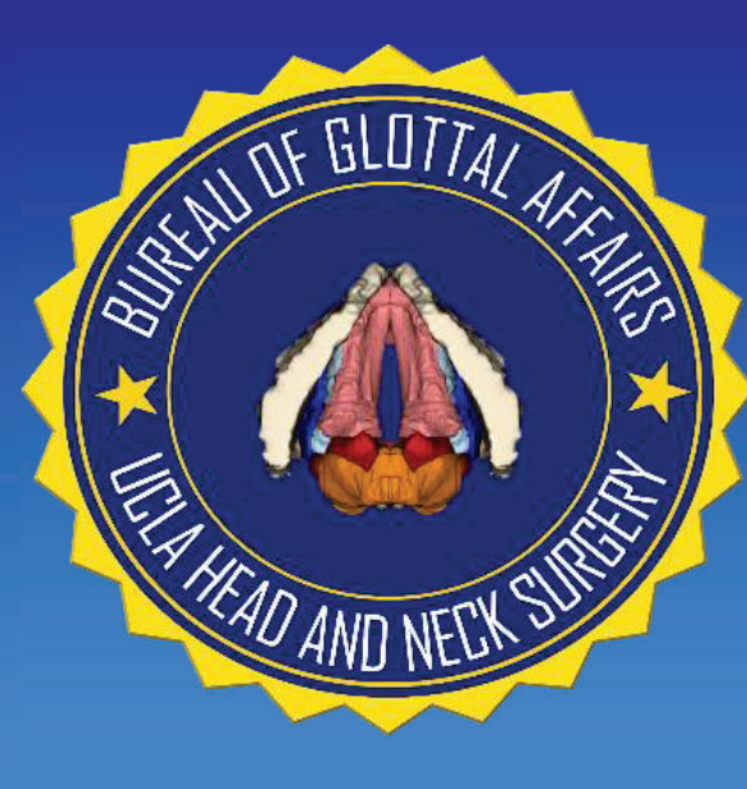
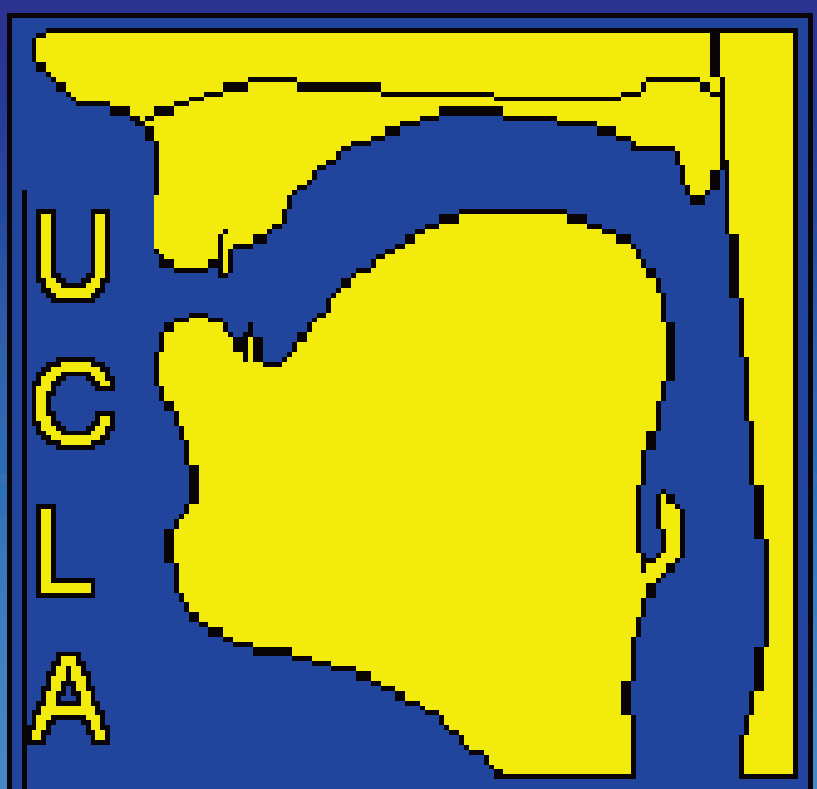




Acoustic Properties of Subtypes of Creaky Voice

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Introduction

- “Creaky voice” refers to a number of different kinds of voice production with similar percepts.
- Our goal is to explore the possible types of creaky voice, give a clear definition to each type, and analyze the acoustic properties of each type.

Prototypical creak

Prototypical creaky voice has three key properties:

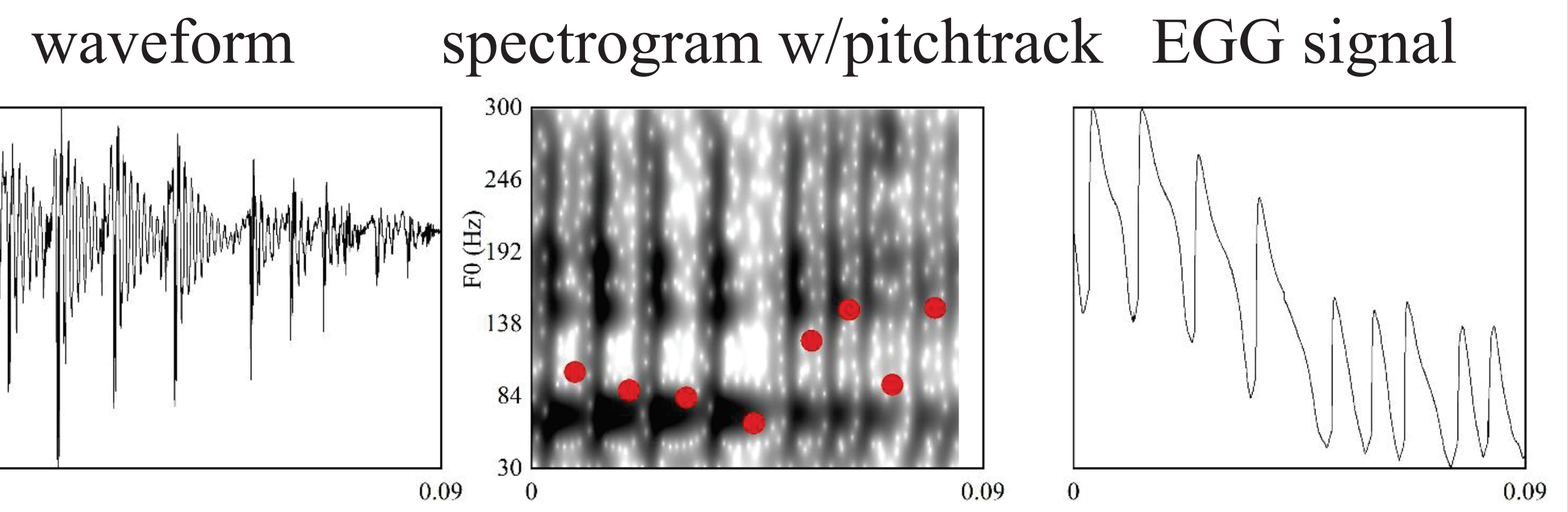
- Low rate of vocal fold vibration (F0), w/ damped pulses
- Irregular F0, random or multiply pulsed
- Constricted glottis: vocal folds are close together, with a small peak glottal opening and a long closed phase (indexed here by EGG Contact Quotient ≥ 0.60), and thus with low airflow

From our existing audio recordings with EGG from several languages, speech tokens were found with 1, 2, or 3 of these properties. (Use the QR code at top right to listen.)

Prototypical creaky voice example: all 3 properties

(1) Low F0 + Irregular F0 + Constricted glottis

(F0: 63 to 150 Hz; CQ: 0.6)

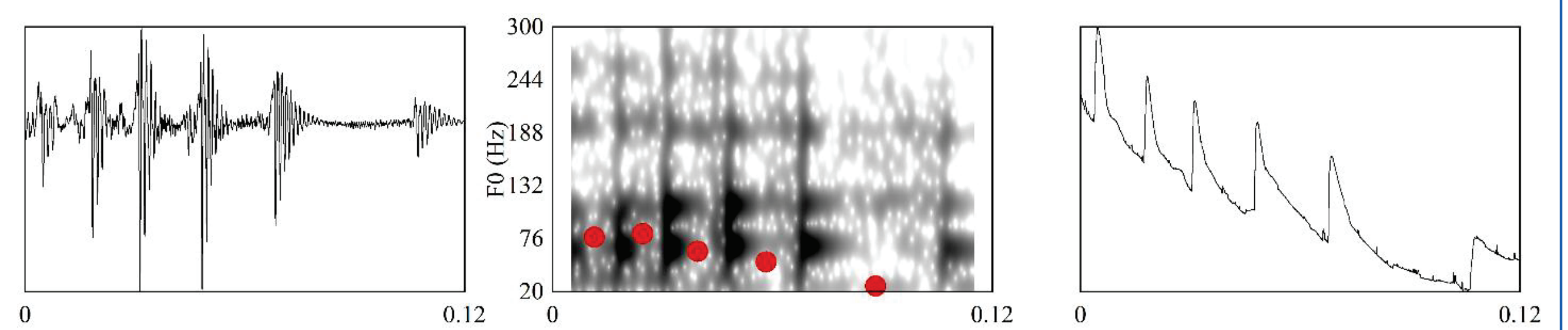


Three key properties

- Low F0 and irregular F0 each suffice on their own for a creaky percept in informal listening by the authors;
- Constricted glottis alone is NOT sufficient for a creaky percept in informal listening by the authors.

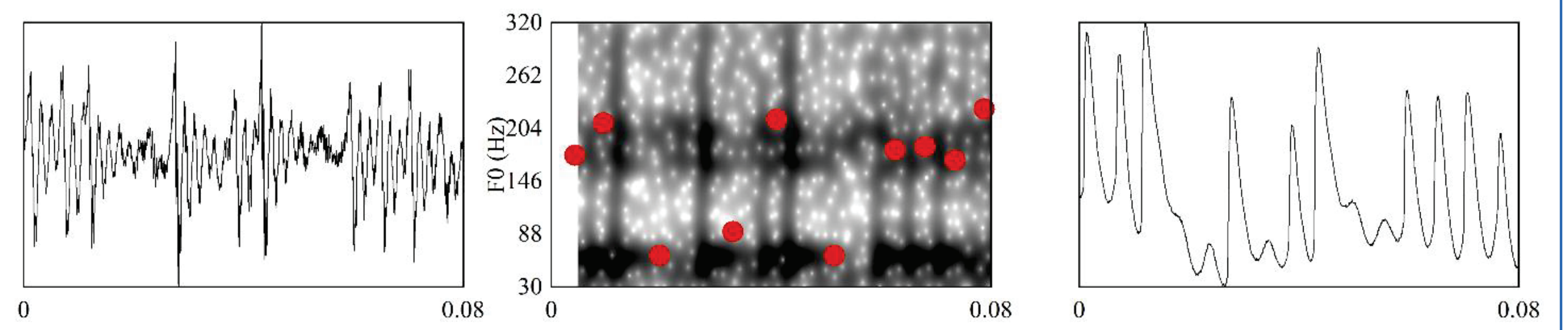
(2) Low F0 → Creaky

(F0: 26-81 Hz; CQ: 0.31, spread glottis)



(3) Irregular F0 → Creaky

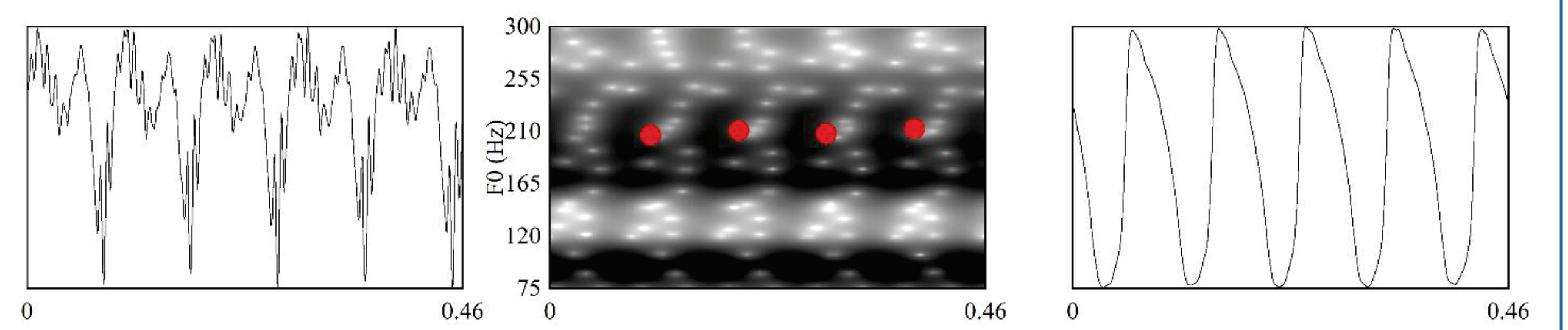
(F0: 62-246 Hz, mix of random and period-doubled; CQ: 0.38, spread glottis)



(4) Constricted glottis → Not creaky

(F0: 211 Hz; CQ: 0.61, constricted)

TENSE VOICE

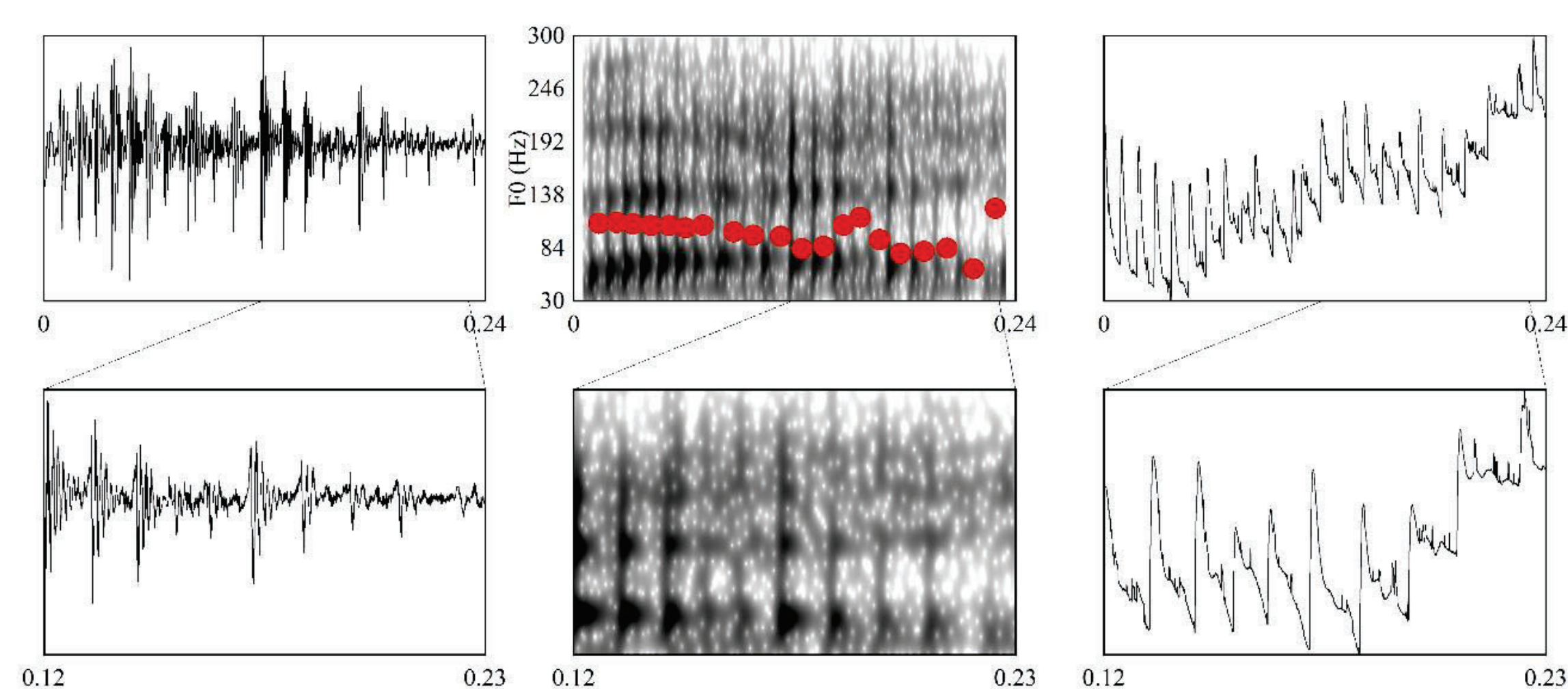


Combinations of properties

(5) Low F0 + Irregular F0 → Creaky

(F0: 62-124 Hz; CQ: 0.34, spread glottis)

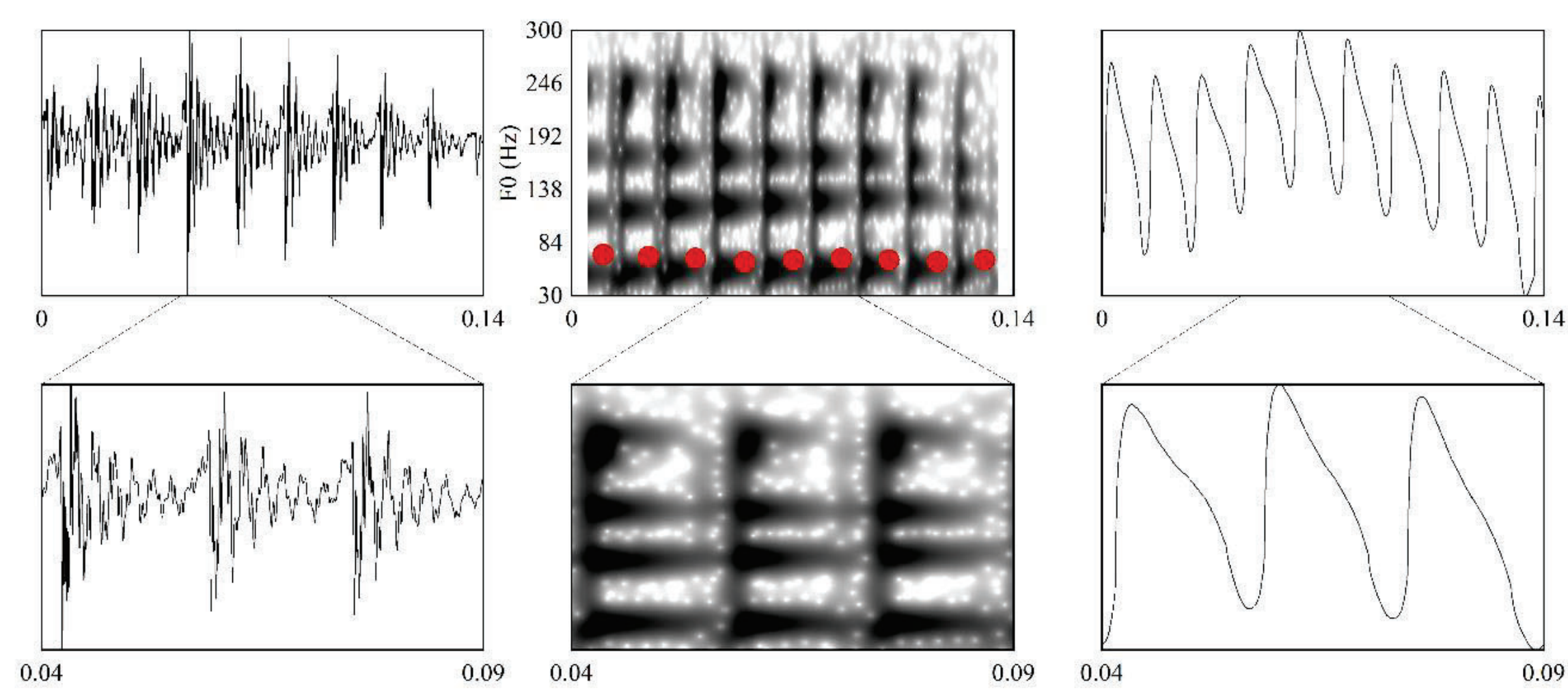
SPREAD GLOTTIS CREAK (see also (2) + (3))



(6) Low F0 + Constricted glottis → Creaky

(F0: 67 Hz; CQ: 0.63, constricted glottis)

VOCAL FRY



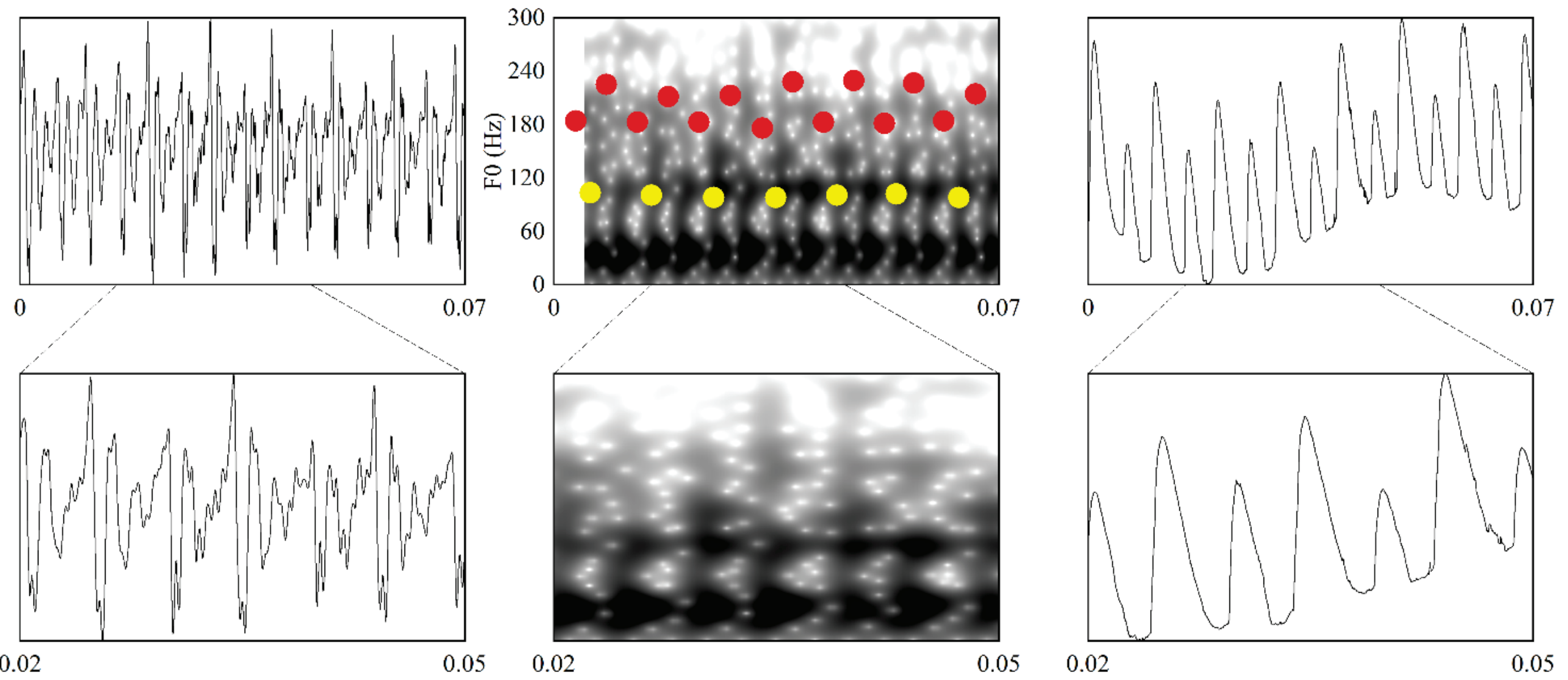
Irregular (high) F0 + Constricted glottis – Not found with creaky percept (yet)

Multiple-pulsing

- Multiple-pulsing (e.g. period doubling) is a special case of irregular F0, as it is not random;
- By itself is NOT sufficient for creaky percept, instead sounds rough.
- Often the fundamental period includes the doubled pulses, not just a single pulse, so a lower F0 is possible (yellow dots in pitchtracks below) – if this is low enough, then percept is creaky

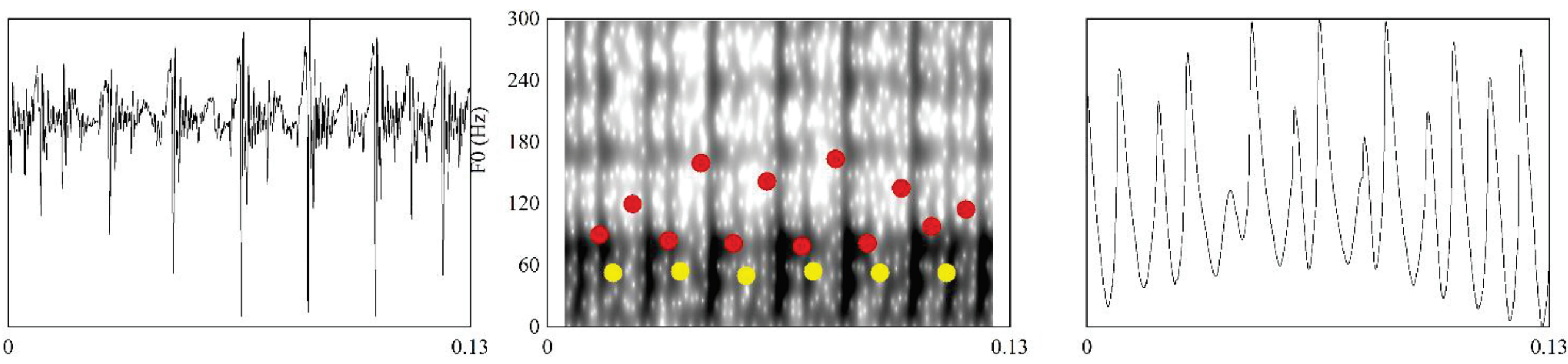
(7) Multiple-pulsing alone → Not creaky

(lower F0 (yellow dots): 100 Hz; CQ: strong pulse: 0.46; weak pulse: 0.47; mean: 0.47)



(8) Multiple-pulsing + Low F0 → Creaky

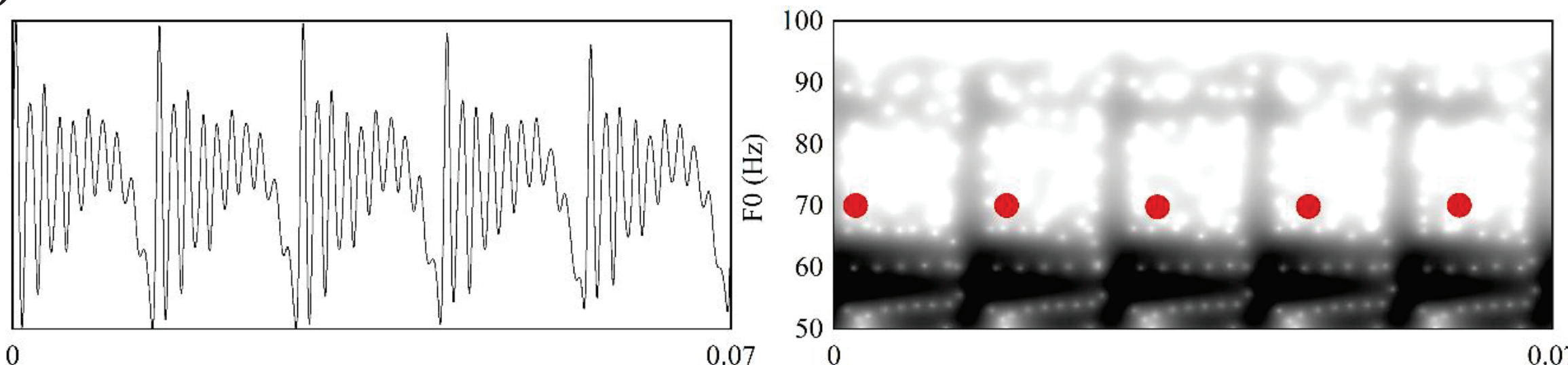
(lower F0 (yellow dots): 50 Hz; CQ: weak pulse: 0.36; strong pulse: 0.43)



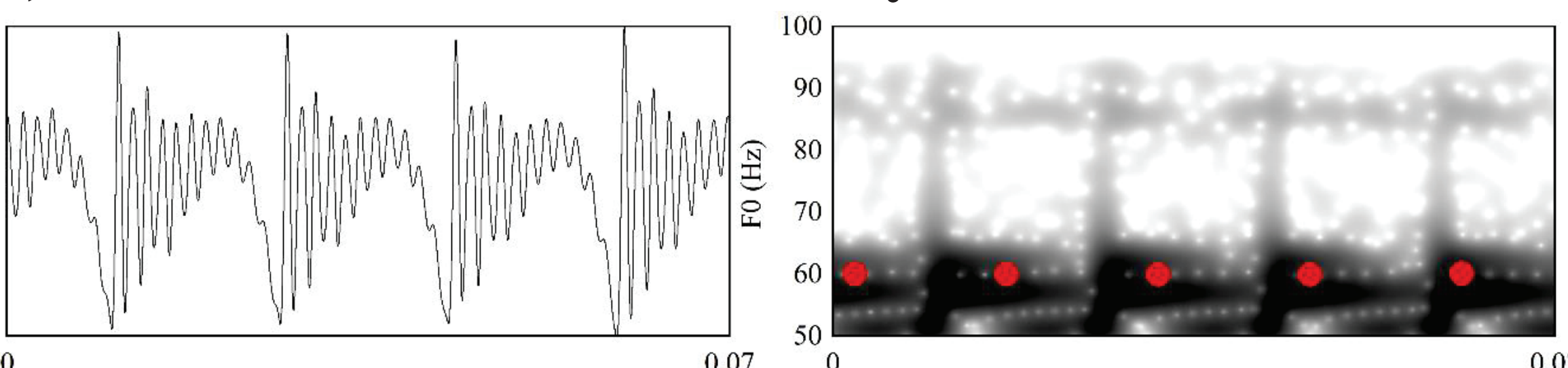
We test our observations from natural speech through informal listening to Klatt synthesis in Praat. →

Klatt Synthesis in Praat

(9) Modal baseline: F0 = 70 Hz

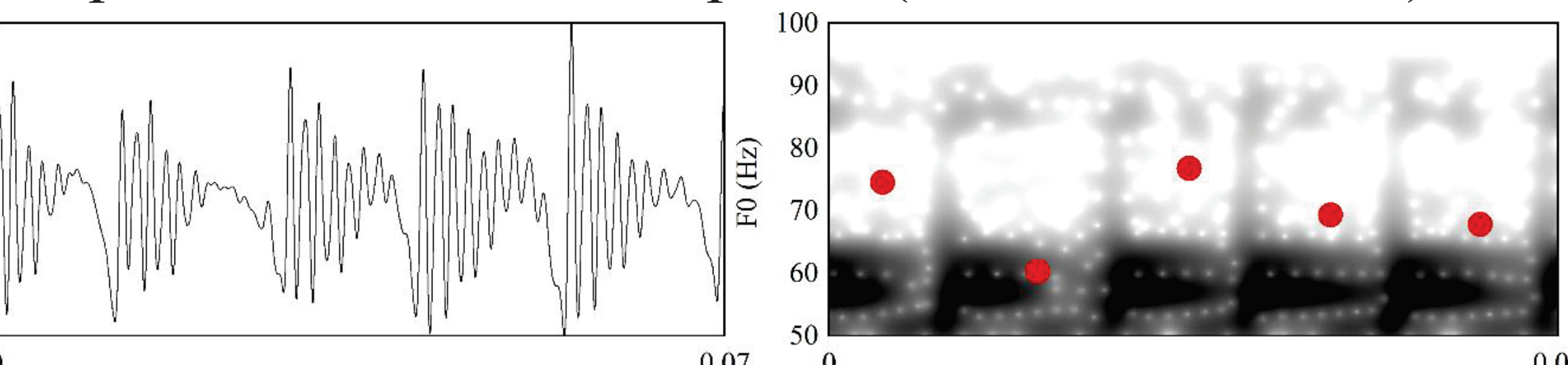


(10) Low F0: F0 = 60 Hz → Creaky



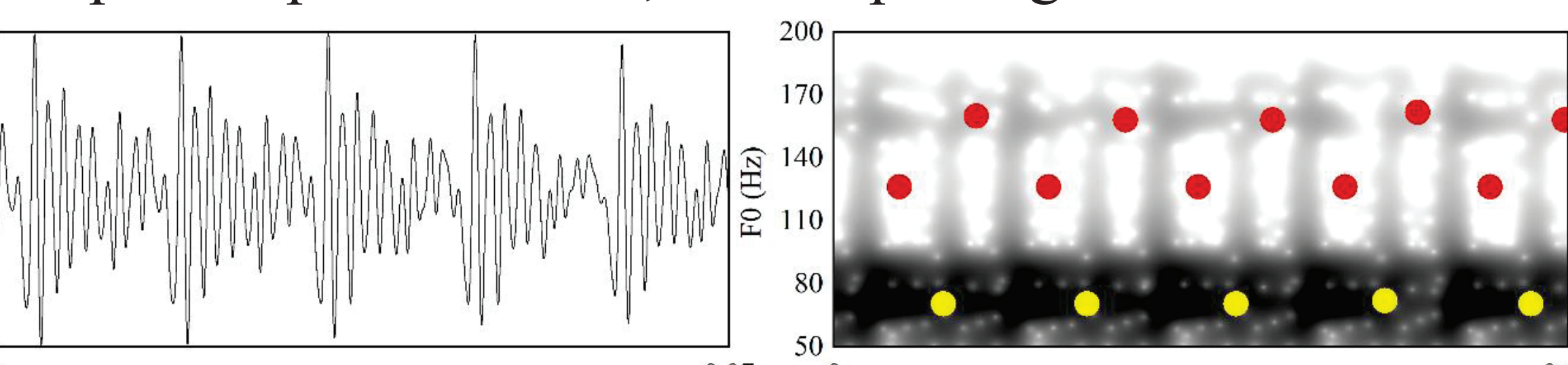
(11) Irregular F0: F0 = 70 Hz → Creaky

Klatt param: flutter = 0.9; raspiness (Praat Vocal Toolkit) = 200%



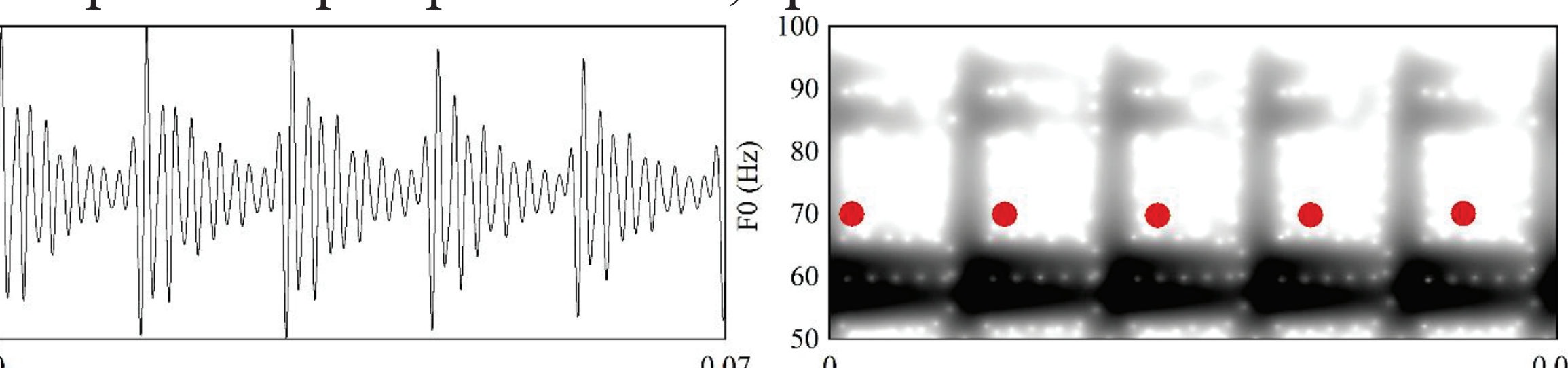
(12) Period-doubling: lower F0 (yellow dots) = 70 Hz → Not Creaky

Klatt param: pitch: 140 Hz; double pulsing: 0.5



(13) Constricted glottis: F0 = 70 Hz → Not Creaky

Klatt param: open phase = 0.1; spectral tilt = -40



Acoustics

- Irregular F0 can be measured as pulse-to-pulse jitter; by the standard deviation of the F0; or, since it is perceived as spectral noise, as a low Harmonic-to-Noise Ratio.

● Strength of period doubling can be measured as relative strength of spectrum subharmonics (Subharmonic to Harmonic Ratio).

● H1–H2 correlates with the glottal Open Quotient and with Contact Quotient measures from electroglottography, thus indicating glottal constriction/spreading.

Acoustic correlates (signature) of each type

Type – sounds creaky	Low F0	Low HNR	High SHR	Low H1–H2	High CQ
Low F0	✓		(optional)		
Irregular F0		✓		(not defined)	
Prototypical creak	✓	✓		✓	✓
Vocal fry	✓			✓	✓
Spread glottis creak	✓	(and/or)	✓	NO, high	
Multiple-pulsed spread glottis creak	✓	(and/or)	✓	NO, high	
Type – does not sound creaky					
Tense voice				✓	✓
Multiple-pulsed			✓		

Conclusion

- Each type of creaky voice has a different (sub)set of the three key properties: low F0, irregular F0, constricted glottis. None are necessary, and only the first two

are sufficient by themselves for a creaky percept.

- Each has its own acoustic correlates, thus each type of creaky voice has a different acoustic signature.
- Thus acoustic analysis of creaky voice will give different results depending on which kind of creak is at issue.
- No single acoustic measure is criterial for all types of creaky voice. Most notably:
- While H1-H2 is the most common measure, glottal constriction is neither necessary nor sufficient for a creaky voice percept! – By itself it does not give a creaky percept, and creaky voice can have spread glottis.
- Low/irregular F0 are good correlates for phonemic creaky voice.

>> QR code above for sound files and references