



Fuzzy Categorization and limits of Intonational Phonology

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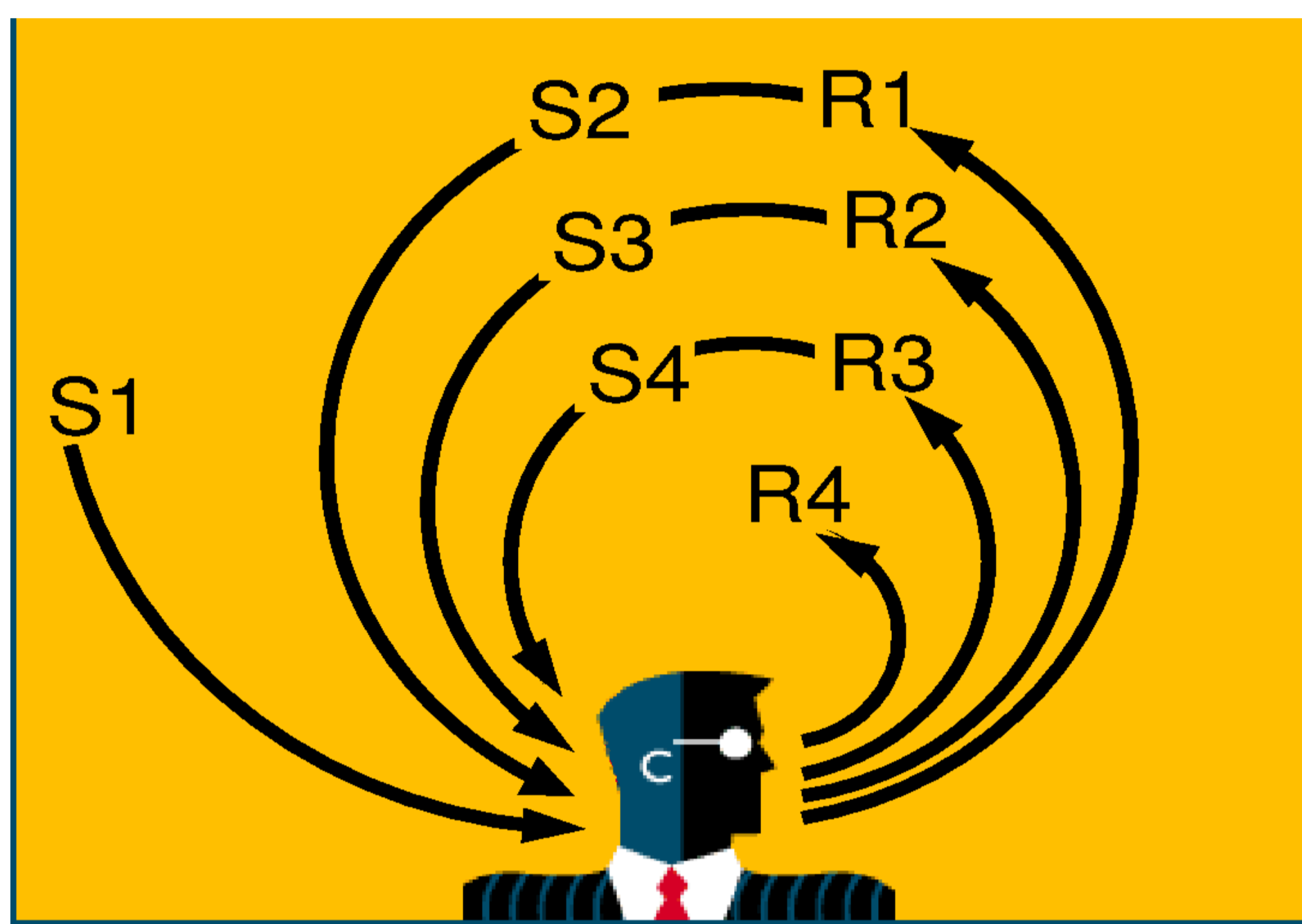
BACKGROUND

- Although f_0 is continuously variable, linguists treat intonation in terms of discrete categories (1, 2, 3).
- There has been little behavioural evidence (4), however, to show that these categories exist in the minds of speakers rather than merely being endpoints of a continuum.

Q: Is intonation in speech a categorical or a gradient property?

A: In intonation, mental representations involve both.

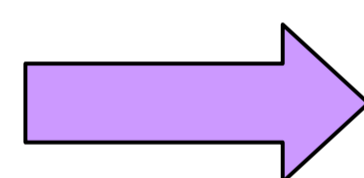
METHOD: ITERATIVE MIMICRY



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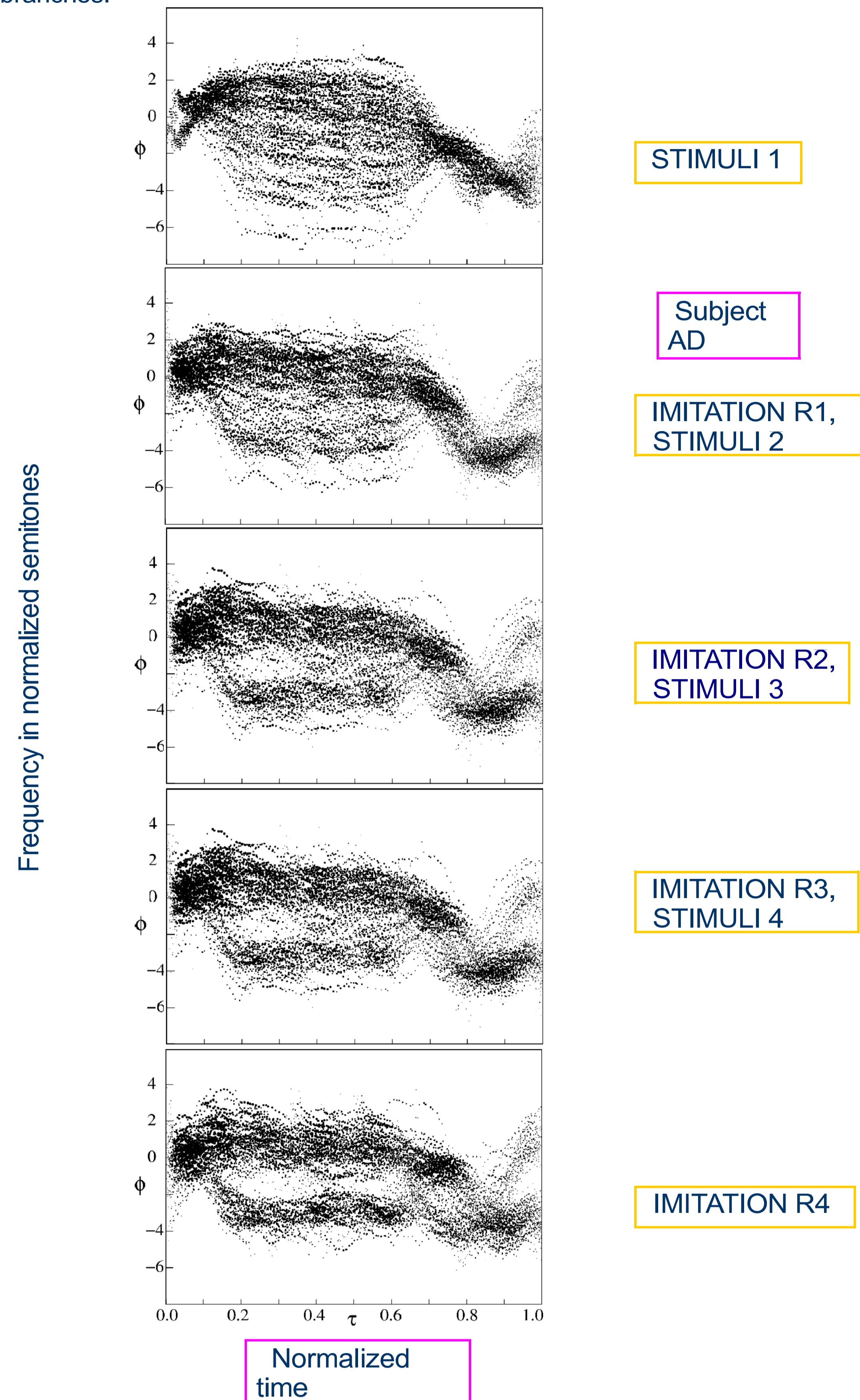
IMITATIONS
(RESPONSES)

- Ten naïve speakers of Southern British English, four sessions each.
- 120 initial utterances were made, each resynthesized with a unique, physiologically possible, f_0 contour. Sentences were about 1.2 seconds long.
- In session 1, subjects mimicked each initial utterance. They heard S1 and produced R1. Each production was trimmed, amplitude-normalised, and stored.
- In sessions 2 through 4, the subject mimicked his/her own productions from the preceding session. (S2 → R2, ...)
- The f_0 track of each utterance obtained with ESPS get_f0. Each track was time-normalized.



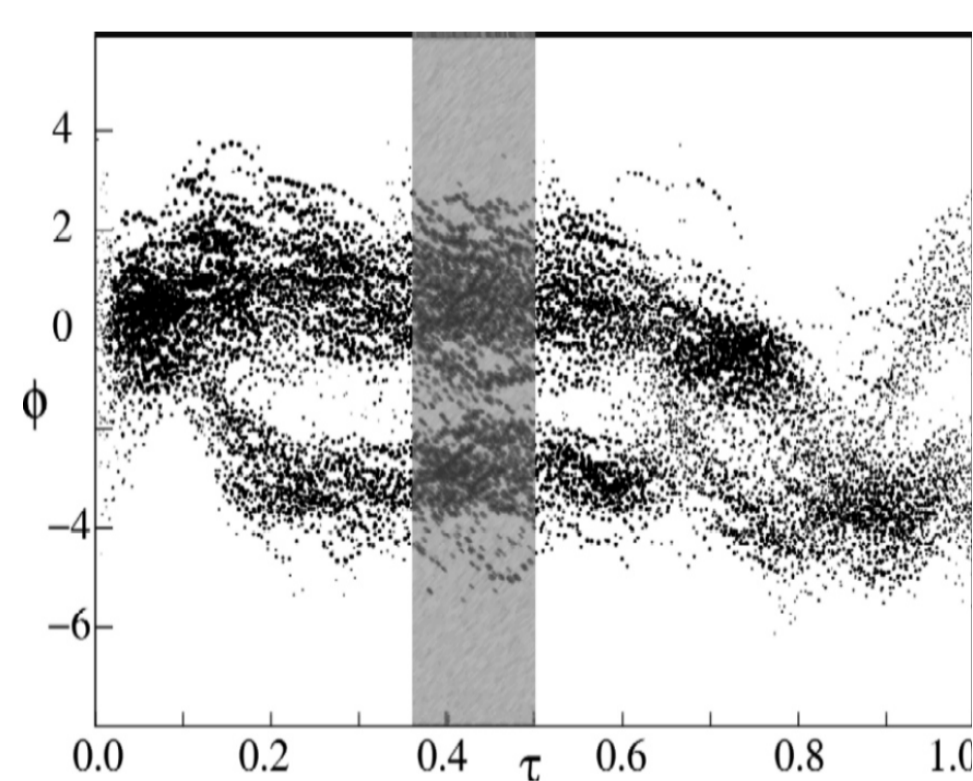
RESULTS

- In the first session, the produced f_0 contours generally resembled those of the initial stimuli but showed some grouping.
- As sessions proceeded, f_0 contours for most subjects progressively collapsed into two distinct, separate sets or branches.

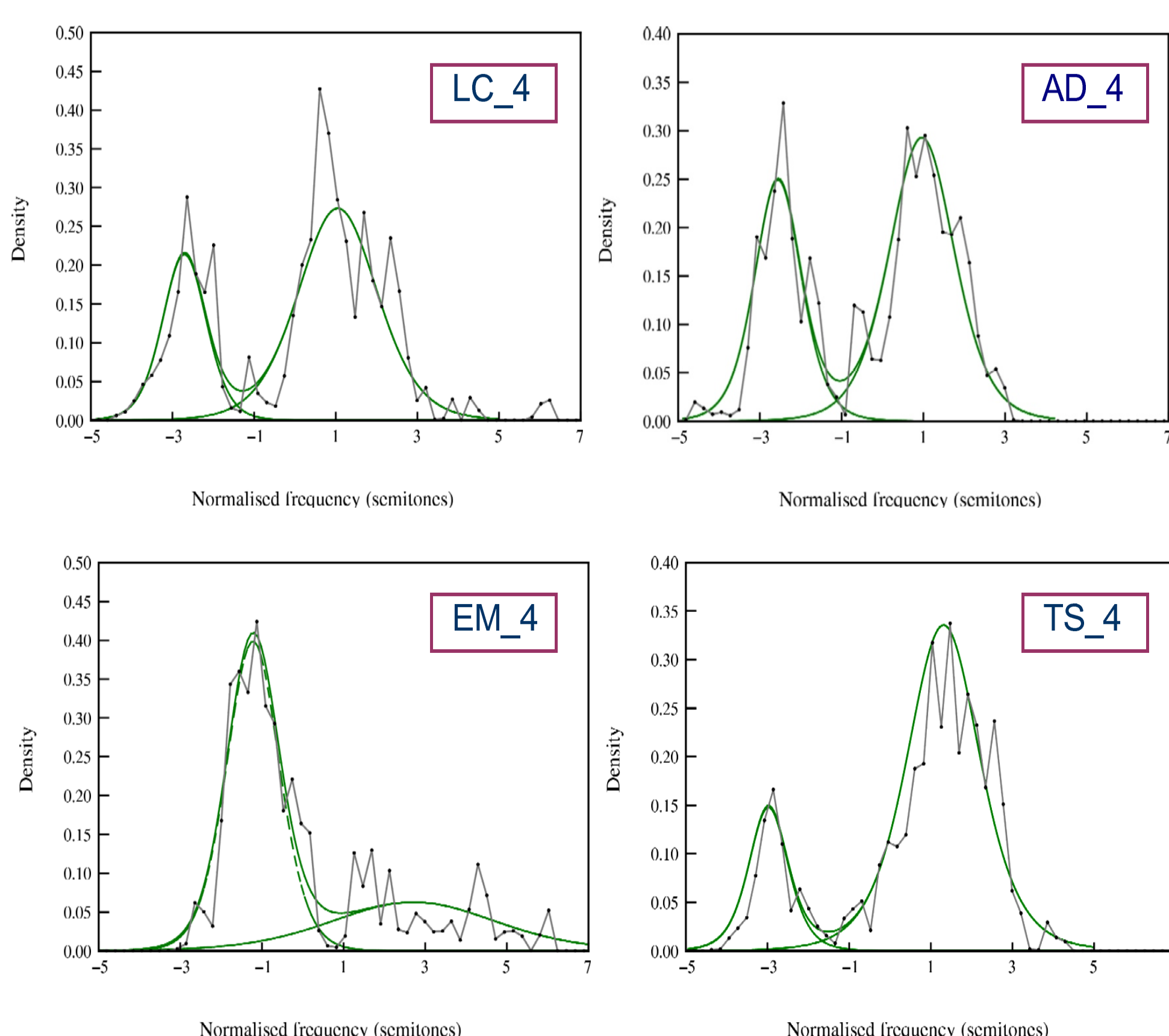


STATISTICAL ANALYSIS

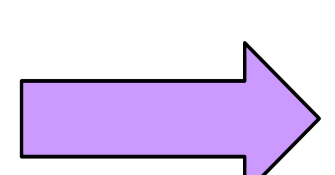
- To test for the presence of the two branches in each session, we examined a slice of the data near the middle of each utterance.



- Using a Bayesian Markov-chain Monte Carlo procedure, we determined the likelihood ratio R for fits of a single t -density and of two t -densities to the data. (The data had slightly longer tails than Gaussians could accommodate, requiring t -densities.)
- For nine of the ten participants, a fit with two densities was superior at $R < .0001$ in sessions 2 through 4.



Fits (green lines) to the distribution of fundamental frequency in Response 4 (black lines and dots) for four different participants. Each fitted function is the sum of the two t -densities that are plotted separately.



CONCLUSIONS

- Subjects can perceive and imitate intonation contours that are far from phonological archetypes, retaining substantial phonetic detail.
- Over several successive sessions, however, their imitations tend to converge onto a small set of distinct contours.
- These distinct contours are common English intonation contours. Mathematically, they are stable attractors of the mapping between stimuli and responses.
- Stable attractors and the related Perceptual Magnet Theory of Phonetic Learning (5, 6) suggest that linguistic categories may emerge from a continuously variable space.
- These attractors may equate to some form of latent mental categories: they delimit sets of intonation contours that are treated similarly.
- A purely symbolic representation of intonation, however, is insufficient to explain the facts of mimicry.

SPECULATIONS

- The distribution of contours that adults hear over time will have peaks at attractors.
- Children may construct their own attractors based on the adult distribution.
- This could underlie transmission of the intonational aspects of a language from one generation to another.

NOTES

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