Prosodic Convergence During and After a Cooperative Maze Task

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1. CONVERGENCE EFFECTS IN COMMUNICATION

In conversational tasks such as cooperative gameplay or simultaneous speech,
- Convergence effects found using *quantitative measures*:
  - Speech rate, pitch, intensity and kinematic trajectories (e.g., Levitan & Hirschberg, 2011; Tiede et al., 2010)
- Convergence effects found using *qualitative measures*:
  - Occurrence and frequency of prosodic contours (Gravano et al., 2014)
- No prior work has shown relationship between convergence and *qualitative* and *quantative* measures of prosody.
- Are convergence effects *maintained* after conversation has concluded?

2. RESEARCH OUTLINE

1) How do prosodic properties such as **boundary strength**, **choice of boundary tone** and the **quantitative properties of those tones** differ when a speaker is engaged in an individual speech task vs. when two speakers converse in a cooperative speech task?

2) If speakers converge on prosodic patterns during the cooperative task, is the pattern maintained after the task has concluded?

- Simultaneous recording of speech articulator movements from a dyad using **two NDI electromagnetic articulography systems (EMAs)**
- One male dyad (M1 & M2) & one female dyad (F1 & F2); all speakers of American English
- Maze task types
  1. **Before** the cooperative maze: each speaker navigates a maze individually.
  2. **During** the cooperative maze: both speakers take turns navigating a maze together.
  3. **After** the cooperative maze: each speaker repeats the individual maze task.

Example Cooperative Maze

What speaker A sees   What speaker B sees
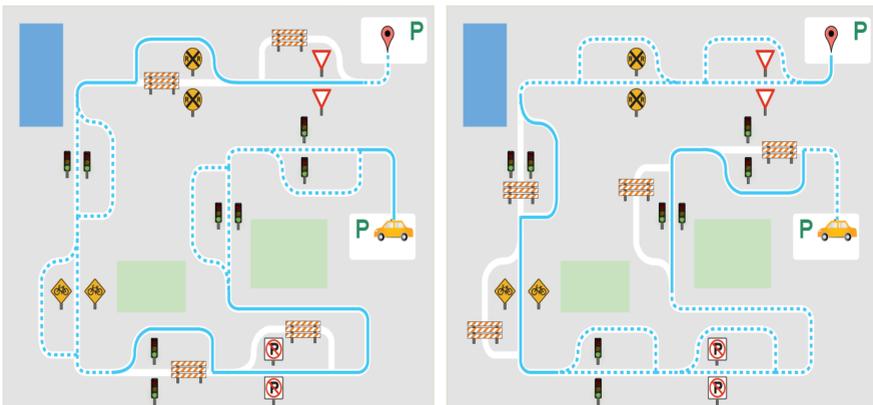
✓ **Target sentence**
  '*And then you go* [between/beside] *the next two* [lights/signs].'

How do phonetic properties of each speaker's prosodic structure differ **before**, **during** and **after the cooperative maze task**?

3. MEASUREMENTS

- **Acoustic Measures**
  1) Sentence duration (ms)
  2) Final lengthening (*FL*) = $\dfrac{\text{sentence–final target word duration (ms)}}{\text{sentence duration (ms)}}$
  3) Occurrence frequency of sentence-final boundary tones (H% vs. non-H%)
  4) Value of high F0 peaks (Hz) in sentence-final target words (*lights* or *signs*)

- **Kinematic Measures**
  1) Tongue Tip (TT) kinematics measured for the word-final consonant(s) in phrase-medial '*beside*' versus phrase-final '*signs*'

  TT landmarks defined using velocity profile at right →
  a. Movement duration
  b. Displacement
  c. Peak velocity
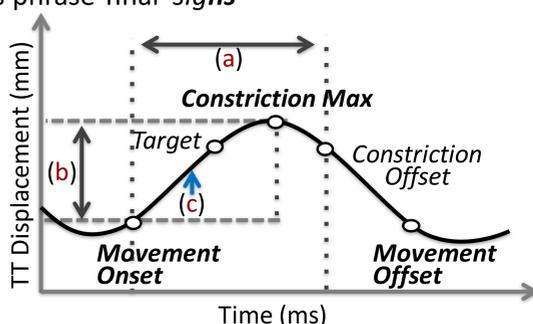
  2) TT boundary lengthening = TT duration (a) in '*signs*' – (a) in '*beside*'

4. MALE SPEAKER PAIR RESULTS

- Both M1 & M2 show convergence effects in *sentence durations* during, but not after, the cooperative maze task.

Sentence Dur. (mean diff.)	
before	91 ms
during	16 ms
after	401 ms

	FL M1	*FL* M2
before	.29	.29
during	.32	.31
after	.27	.30

- Larger boundary strength (*FL*) for both speakers during the cooperative maze task

F0 peaks (mean diff.)	
before	18 Hz
during	0 Hz
after	11 Hz

- M1's target *F0 peak values* became lower and more similar to M2's *during*, and to a lesser extent, *after* the cooperative maze task
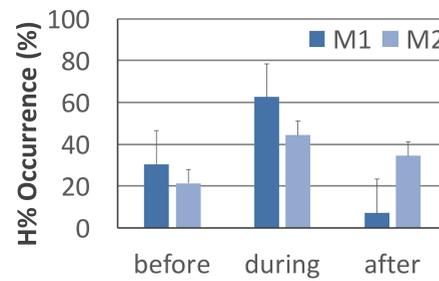
Increased choice of a rising boundary tone (*H%*) *during* the cooperative maze task
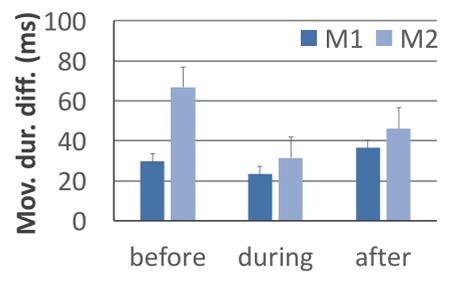
M2's **TT boundary lengthening** became smaller and more comparable to M1's *during* & *after* the cooperative maze task

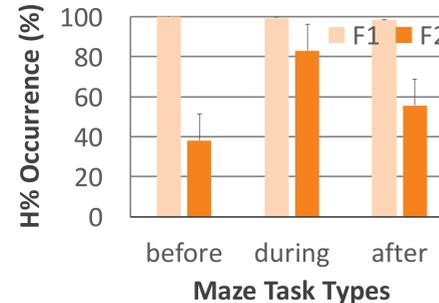- No convergence effect on **TT displacement** or **peak velocity**

5. FEMALE SPEAKER PAIR RESULTS

- Temporal structures of F2's speech became more similar to F1's over the course of the experiment.
- No significant changes occurred in F1's speech throughout experiment.

Sentence Dur. (mean diff.)			*FL* F1	*FL* F2
before	669 ms	before	.27	.24
during	127 ms	during	.26	.28
after	247 ms	after	.26	.28

- F1 consistently used a rising boundary tone (*H%*) throughout the study (99%).
- F2 shifted her boundary tone type *during*, and to a lesser extent, *after* the cooperative maze task
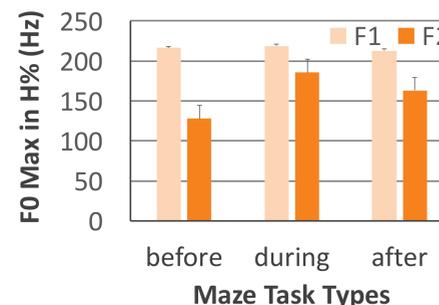
- F1 did not show any significant difference in H targets.
- F2 produced higher *F0 peak values during* & *after* the cooperative maze task.

6. CONCLUSIONS

- Effects of convergence may persist in the speech of one or both conversation partners even after conversation has ended.
- Conversing speakers converge not only in broad measures like speech rate, but also in qualitative and quantitative aspects of prosodic structure.
  - Convergence effects are found in prosodic boundary strength, use of boundary tones, and quantitative properties of boundary tones.
- Our findings raise the possibility that quantitative aspects of prosody (which can be produced by adaptation of speech motor behavior) and qualitative aspects of prosody (which engage the grammar and social interaction) can be modeled as arising from a single system of control.