The mediating effect of information status on acoustic cues to prominence

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Prominence
Prominence

• Why do we perceive some words as more prominent than the others?
<table>
<thead>
<tr>
<th>Non-Prominent</th>
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</table>

Prominence
Prominence

Acoustic Cues

Diminished 0 1 Enhanced
Non-Prominent Prominent
Prominence

Acoustic Cues

Diminished  →  Enhanced

Pitch Accents

Unaccented  L*  H*  L*+H  L+H*

Non-Prominent  0  1  Prominent
Prominence

Acoustic Cues

Diminished  Enhanced

Pitch Accents

Unaccented  L*  H*  L*+H  L+H*

Information Structure

Given  Salient  New  Uncertain  Contrastive

Non-Prominent  0  1  Prominent
Speech Style

• Prior work has examined the relationship between IS and prominence/pitch accent through:
  • experimental methods with minimally contextualized utterances
  • excerpts from conversational speech
    (Birch & Clifton, 1995; Breen et al., 2011; Cole et al., 2010; Ito & Speer, 2008; Terken & Nooteboom, 1987)

• There may be discrepancies between the use of pitch accents in controlled, decontextualized vs. natural, contextualized speech.

• This study analyzes prominence perception in a complete public speech from TED Talk.
Research Question

• How is the perception of *prosodic prominence* influenced by *meaning* (*Information structure*) and *signal-driven factors* (*acoustic cues, pitch accents*)?
Methods: Materials

• TED Talk called “Try Something New for Thirty Days” delivered by a male speaker of American English in a clear and engaging manner (361 words, $t = 2'25''$).
Methods: Perception Experiment

• 35 listeners [American English]
• Rapid Prosody Transcription (Cole et al., 2010).
• “words that stand out in the speech stream by virtue of being louder, longer, more extreme in pitch, or more crisply articulated than other words in the same utterance.”
Methods: IS Annotation

• A simplified version of the RefLex scheme (Riester & Baumann, 2017)

  Smith was very optimistic.
  The polls showed a solid majority for the politician.

  referentially (r-) given
  lexically (l-) new

• Alternative-based contrastive focus (Rooth, 2012)

*The examples adopted from Baumann & Riester (2013)
Methods: Labels for Referential (r-) Givenness

• r-new:
  A car was waiting in front of the hotel. I could see a woman in the car.

• r-bridging:
  I tried to open the door but the lock was rusty.

• r-unused:
  President Barack Obama delivered a brilliant speech in Tucson.

• r-given:
  A car was waiting in front of the hotel. I could see a woman in the car.

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Methods: Labels for Lexical (l-) Givenness & Alternative (alt) Focus

• l-new:
  A car was waiting in front of the hotel. I could see a woman in the car.

• l-given:
  A car was waiting in front of the hotel. I could see a woman in the car.

• alt (semantic alternative):
  Did you call John? No, I called Mary.

*The examples adopted from Baumann & Riester (2013); Baumann et al. (2006)*
Methods: Signal-driven Factors

*Pitch Accents*
- ToBI Annotation Conventions (Veilleux et al., 2006).
- H*, L*, !H*, L+H*, (L*+H, H+!H*)

*Acoustic Cues*
- Max f0 (Hz)
- Mean phone duration: the entire duration of each word divided by the number of phones of the word
- Mean word intensity
- The acoustic cues centered and scaled
Analyses

• Statistical analysis using Generalized Linear Mixed Models
• DV: Binary prominence rating
• Fixed effects
  • Acoustic cues (f0, duration, intensity)
  • IS (r-, l-, alt-levels)
  • Pitch Accents
• Random effect: subject intercept
Prediction 1

- The words with high and bitonal pitch accents are more likely to be perceived as prominent than words with low and downstepped high pitch accents.

![Hypothetical Results](image)
Prediction 2

• The words with enhanced acoustic cues are more likely to be perceived as prominent than words with relatively diminished acoustic cues.
Prediction 3

• The words with new information or contrastive meaning are more likely to be perceived as prominent than words with given information or non-contrastive meaning.

![Hypothetical Results](image)
Results: Perceived Prominence and Accents

Predicted Probability in Prominence Rating

Pitch Accents
unaccented L* !H* H* L+H*
Results: Perceived Prominence and Accents

- L* H-
- L* H-H%
Results: Perceived Prominence and Acoustic Cues
Results: Perceived Prominence and Acoustic Cues
Results: Perceived Prominence and Acoustic Cues

- Predicted Probability in Prominence Rating vs. F0
- Predicted Probability in Prominence Rating vs. Duration
- Predicted Probability in Prominence Rating vs. Intensity
Results: Perceived Prominence and IS

Referential Givenness

- NR (Non-Referential): mostly function words, discourse markers, predicate expressions
- R-new
Results: Perceived Prominence and IS

**Lexical Givenness**

- NL (Non-Lexical): mostly function words, discourse markers, quantifiers
Results: Perceived Prominence and IS
Results: Perceived Prominence and Interaction between f0 and IS

Referential Givenness

• Different effects of f0 on prominence rating across referential meaning
• R-bridging: weak effect of f0
Results: Perceived Prominence and Interaction between f0 and IS

Lexical Givenness

- Different effects of f0 on perceived prominence across lexical givenness
- L-given: emphasis
Results: Perceived Prominence and Interaction between f0 and IS
Results: Perceived Prominence and Interaction between duration and IS
Results: Perceived Prominence and Interaction between Acoustic Cues and Accents

*Pitch Accent*

- Different effects of f0 on perceived prominence across pitch accents
- Unaccented & L*
Results: Perceived Prominence and Interaction between Acoustic Cues and Accents
Research Question

• How is the perception of prosodic prominence influenced by meaning (Information structure) and signal-driven factors (acoustic cues, pitch accents?)
Prominence Perception

• Perceived prominence is significantly related to meaning-driven (IS), signal-driven factors (pitch accents, acoustic cues), and their interaction in consistent with previous findings from conversational speech (Cole et al., 2010).

• \(H^*, L+H^* > L^*, !H^*\) (Hualde et al., 2016).

• Low pitch accents may be perceived as prominent if they are in nuclear position adjacent to a high boundary tone.
Prominence Perception

• Acoustic enhancement predicts perceived prominence.
• Intensity is not a strong cue to prominence in this sample of public speech style. Listeners are sensitive to the cues that speakers use to encode IS distinctions.
• The same acoustic cues are perceived differently depending on IS.
Prominence Perception

• Referential ≠ Lexical IS:
  • Each level contributes independently to prominence perception.
• New (?), Contrastive > Accessible, Given
• Some function words and discourse markers can still be perceptually salient.
Speech Style

• In this motivational public speech style, acoustic cues and accenting patterns are found to be different from what has been reported for laboratory and conversational speech (Im et al., 2018).
Speech Style

• Comparison between the public speech (publ) and conversational speech (conv) from the Buckeye corpus (Cole et al., 2014)
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Conclusion

• The perception of prominence is influenced by meaning-driven and signal-driven factors, and their interaction.

• Signal cues are weighted differently by IS, and referential givenness is differentiated from lexical givenness in American English.

• This study shows that speech style is also an important factor in the analysis of prosodic prominence.

Thank you!
Selected References


A few years ago, I felt like I was stuck in a rut, so I decided to follow in the footsteps of the great American philosopher, Morgan Spurlock, and try something new for 30 days. The idea is actually pretty simple. Think about something you've always wanted to add to your life and try it for the next 30 days. It turns out, 30 days is just about the right amount of time to add a new habit or subtract a habit -- like watching the news -- from your life. There's a few things I learned while doing these 30-day challenges. The first was, instead of the months flying by, forgotten, the time was much more memorable. This was part of a challenge I did to take a picture every day for a month. And I remember exactly where I was and what I was doing that day. I also noticed that as I started to do more and harder 30-day challenges, my self-confidence grew. I went from desk-dwelling computer nerd to the kind of guy who bikes to work -- for fun. Even last year, I ended up hiking up Mt. Kilimanjaro, the highest mountain in Africa. I would never have been that adventurous before I started my 30-day challenges. I also figured out that if you really want something badly enough, you can do anything for 30 days. Have you ever wanted to write a novel? Every November, tens of thousands of people try to write their own 50,000-word novel from scratch in 30 days. It turns out, all you have to do is write 1,667 words a day for a month. So I did. By the way, the secret is not to go to sleep until you've written your words for the day. You might be sleep-deprived, but you'll finish your novel. Now is my book the next great American novel? No. I wrote it in a month. It's awful. But for the rest of my life, if I meet John Hodgman at a TED party, I don't have to say, "I'm a computer scientist." No, no, if I want to, I can say, "I'm a novelist."
GLMMs for Perceived Prominence ~ IS, Acoustic Cues, Accent

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Random Effects: (1|subject)
Model 1: Perceived Prominence ~ IS, Acoustic Cues, Accent, Interaction with F0 (Main Effects)

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Model 1: Perceived Prominence ~ IS, Acoustic Cues, Accent, Interaction with F0 (Interaction)

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Model 2: Perceived Prominence ~ IS, Acoustic Cues, Accent, Interaction with Duration (Main Effects)

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Model 3: Perceived Prominence ~ IS, Acoustic Cues, Accent, Interaction with Intensity (Main Effects)

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<td>&lt;.01</td>
</tr>
</tbody>
</table>
## Model 3: Perceived Prominence ~ IS, Acoustic Cues, Accent, Interaction with Intensity (Interaction)

<table>
<thead>
<tr>
<th></th>
<th>est.</th>
<th>SE</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>r-given:intensity</td>
<td>0.17</td>
<td>0.09</td>
<td>1.87</td>
<td>0.06</td>
</tr>
<tr>
<td>r-bridging:intensity</td>
<td>-0.31</td>
<td>0.14</td>
<td>-2.14</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>r-unused:intensity</td>
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<td>0.14</td>
<td>3.47</td>
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</tr>
<tr>
<td>r-new:intensity</td>
<td>1.52</td>
<td>0.13</td>
<td>11.70</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>l-given:intensity</td>
<td>-0.95</td>
<td>0.13</td>
<td>-7.47</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>l-new:intensity</td>
<td>-0.69</td>
<td>0.08</td>
<td>-8.3</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>alt:intensity</td>
<td>-0.38</td>
<td>0.12</td>
<td>-3.06</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>intensity:L*</td>
<td>-0.28</td>
<td>0.18</td>
<td>-1.55</td>
<td>0.12</td>
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<tr>
<td>intensity:!H*</td>
<td>0.21</td>
<td>0.15</td>
<td>1.41</td>
<td>0.16</td>
</tr>
<tr>
<td>intensity:H*</td>
<td>0.19</td>
<td>0.09</td>
<td>2.25</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>intensity:L+H*</td>
<td>-0.20</td>
<td>0.09</td>
<td>-2.29</td>
<td>&lt;.05</td>
</tr>
</tbody>
</table>
## Accent and IS in the Speech

<table>
<thead>
<tr>
<th>Model</th>
<th>Type</th>
<th>DV</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>M4</td>
<td>Chi-square test</td>
<td>Word count for Unaccented vs. Accented labels</td>
<td>Word count for None vs. Any IS labels</td>
</tr>
<tr>
<td>M5</td>
<td>Chi-square test</td>
<td>Word count for Unaccented vs. Accented labels</td>
<td>Words count for Given vs. Non-given IS labels</td>
</tr>
<tr>
<td>M6</td>
<td>Fisher’s exact test ($n &lt; 5$)</td>
<td>Word count for accent types</td>
<td>All IS labels</td>
</tr>
</tbody>
</table>
Model 4: Unaccented ~ Words not Carrying IS

- Reassigned IS labels and pitch accents to test the difference in accent assignment between words labeled as None vs. Any IS.
Model 5: Unaccented ~ Given Information

- Reassigned IS labels and pitch accents to test the difference in accent assignment between words with Given vs. Non-given information.
Model 6: Accent type ~ IS

• Distribution of pitch accents by IS labels
NR: function words, discourse markers, predicate expressions

• 10 most prominent words with non-referential label
NL: function words, discourse markers, quantifiers

• 10 most prominent words with non-lexical label