Prosodic encoding of informativity

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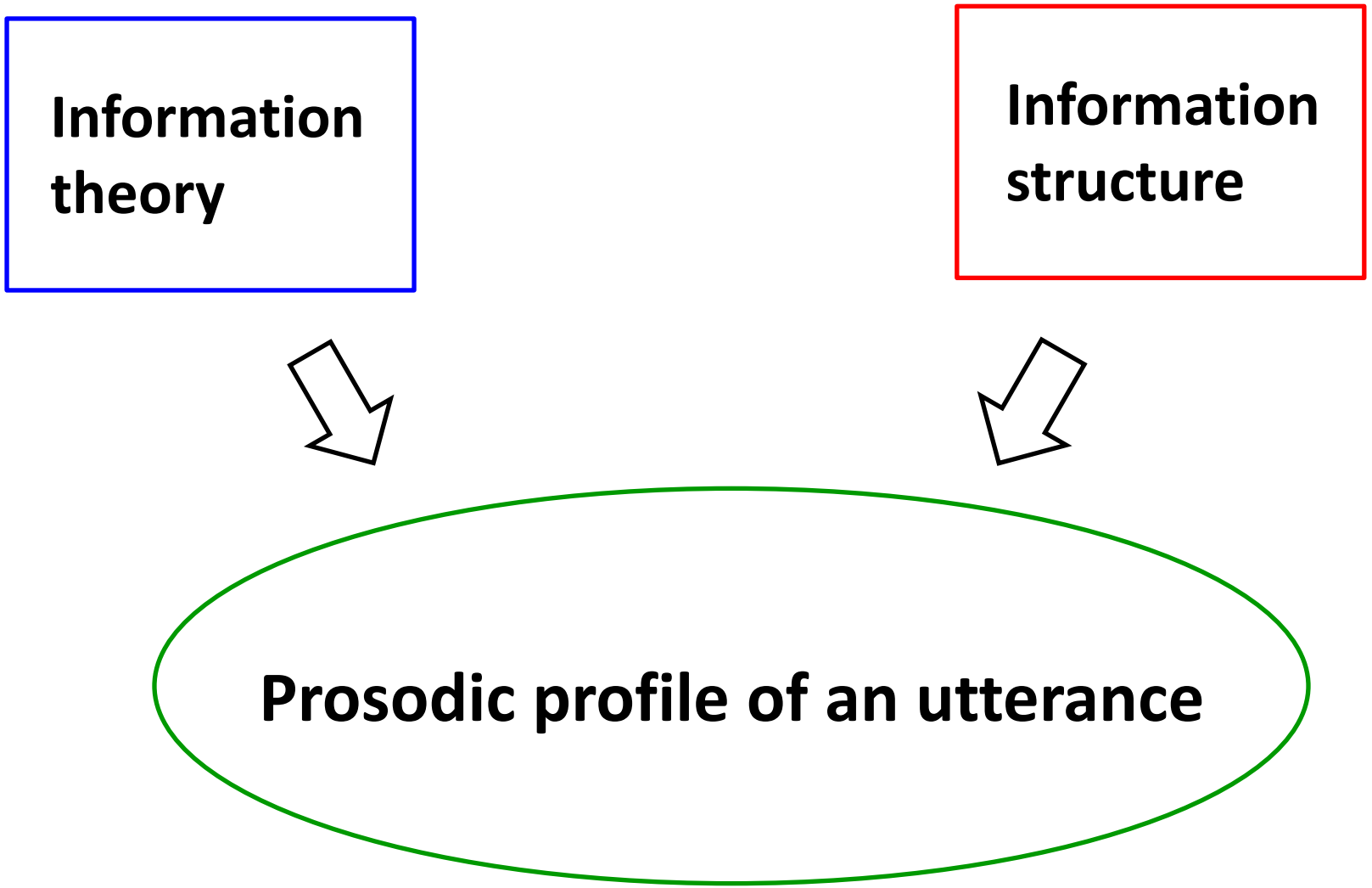

Information theory
Information structure
Prosodic profile of an utterance

What affects the prosodic profile of an utterance?

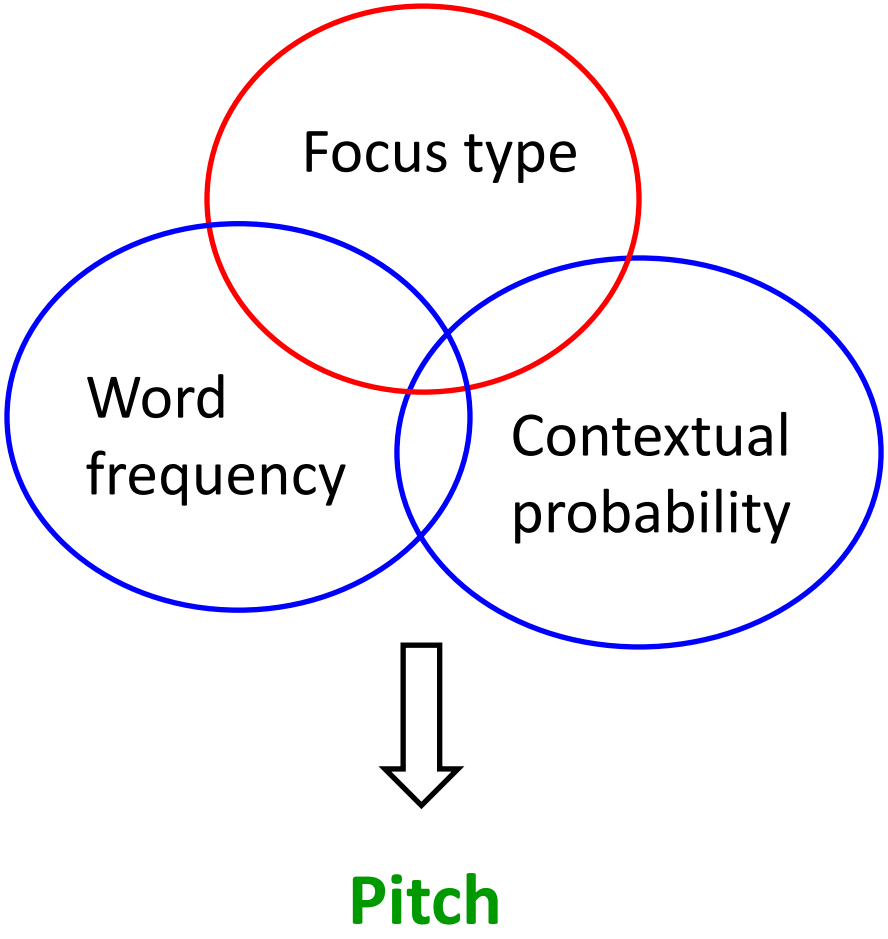
Information theory

- **Word frequency**
  (e.g. Gahl 2008)
  low-freq => high prominence
- **Contextual probability**
  (e.g. Pan & Hirschberg 2000)
  low-prob => high prominence
- ……

Information structure

- **Narrow vs. Broad focus**
  (e.g. Breen, Fedorenko, Wagner & Gibson 2010)
  narrow >> broad
- **Corrective focus vs. New-information focus**
  (e.g. Katz & Selkirk 2011; Chen & Braun 2006)
  corrective >> plain new
- ……

This study



Road map

- Production study:
  - Design
  - Method
- General results
- Speaker-specific patterns

Conditions

	High Contextual Probability	**Low Contextual Probability**
High Word Frequency	**Frequent Word Probable Context**	**Frequent Word Improbable Context**
Low Word Frequency	**Infrequent Word Probable Context**	**Infrequent Word Improbable Context**

Frequent Word in Probable Context: *They kicked **cars** in the garage.*

Infrequent Word in Probable Context: *They kicked **cans** in the garage.*

Frequent Word in Improbable Context: *They kicked **books** in the garage.*

Infrequent Word in Improbable Context: *They kicked **shells** in the garage.*

Word frequency

- SUBTLEXus database (http://expsy.ugent.be/subtlexus/)
- High frequency = 40.16-83.49 per million
- Low frequency = 0.41-13.22 per million
- Log frequency difference in a high/low frequency pair (e.g. *kicked cars/cans in the garage*) = 0.71-2.04

Contextual probability

- Based on results of our norming study
  - ***Rita kicked _____ in the garage.***
- High probability = **2 out of the 3 most popular** (6-14%) responses
- Low probability = never given as response in norming
  No probability difference in a high/low frequency pair (e.g. *kicked cars/cans in the garage*), to avoid frequency-probability correlation

Conditions

(No,) they kicked _____ in the garage.	High Contextual Probability	Low Contextual Probability
High Word Frequency	**cars**	**books**
Low Word Frequency	**cans**	**shells**

Sentences are elicited by questions:

- **New-information focus**: ***What did Rita and Diane kick in the garage?***
- **Corrective focus**: ***I've heard that Rita and Diane kicked dirt in the garage.***
- **VP focus (= baseline)**: ***What did Rita and Diane do?***

(No,) They kicked cars/books/cans/shells in the garage.

2*2*3 within-subject design
8 objects, 4 contexts
48 targets, 48 fillers
16 participants

Method

Participant worked with a partner (lab assistant).

Partner

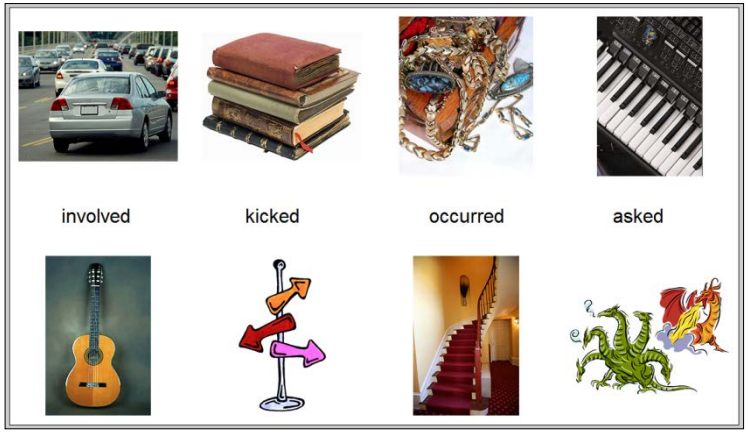
What did Rita and Diane kick in the garage?

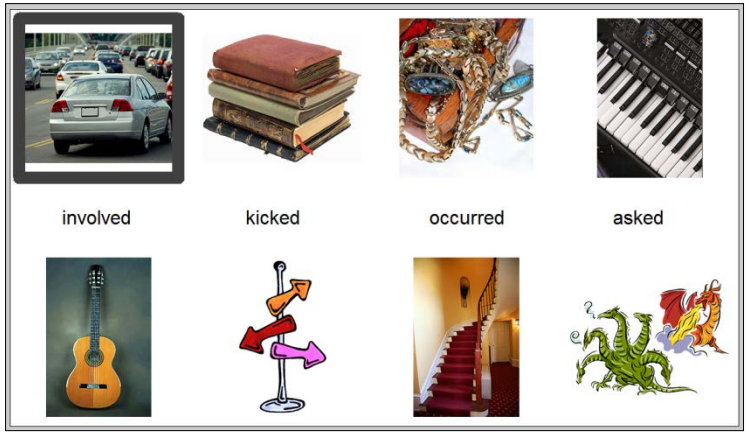
Participant

They kicked cars in the garage.

Partner

Participant





Corrective vs. New-Info vs. VP

they kicked cars/cans/books/shells in the garage

In this experiment,

- Corrective focus = corrective Obj (one word)
- New-information focus = new Obj (one word)
- VP focus = new [Verb Obj LocP] (entire phrase)

Prominence of Obj differs between these focus conditions:
corrective > new-info > VP (e.g. Breen et al 2010, Katz & Selkirk 2011)

We looked for prominence differences of Obj in:

- ~~**Pitch right before Obj (pre-focus compression)**~~
- ~~**Pitch during Obj**~~
- **Pitch right after Obj (post-focus compression)** (e.g. Xu, Chen & Wang 2012)

The roles of word frequency and contextual probability

Focus-Only Hypothesis = Information structure (IS) determines prosodic prominence. Different IS categories remain distinct regardless of word frequency and contextual probability

PROSODIC PROMINENCE OF OBJ	Probable Context	Improbable Context
Frequent Word	**corrective > new-info > VP**	**corrective > new-info > VP**
Infrequent Word	**corrective > new-info > VP**	**corrective > new-info > VP**

- Prior work on focus types has not looked closely at freq and prob
- **BUT** Baker & Bradlow (2009): low-frequency words allowed smaller differences between new vs. given information
  - Casts some doubt on focus-only hypothesis

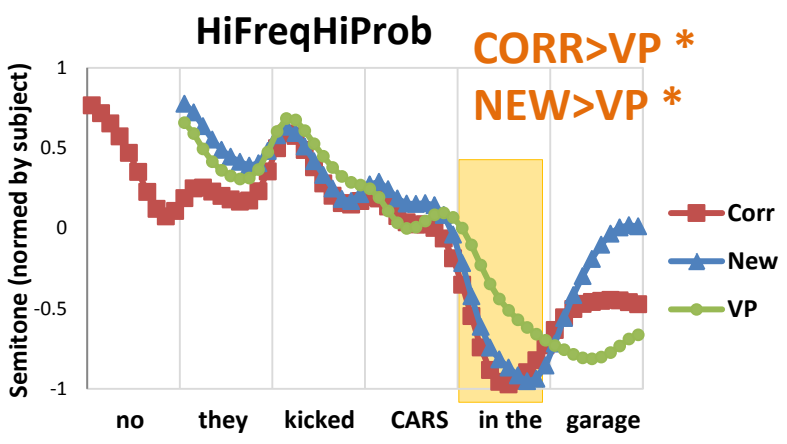
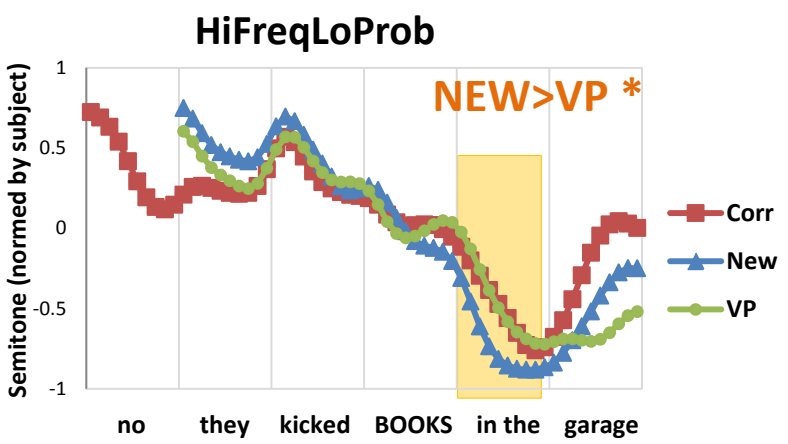
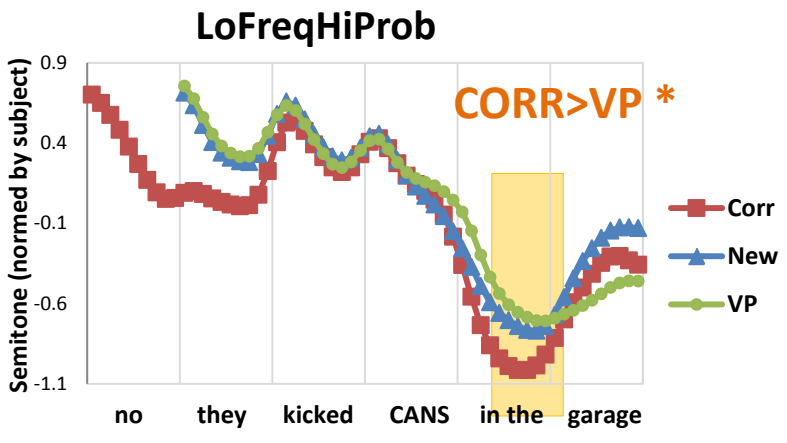
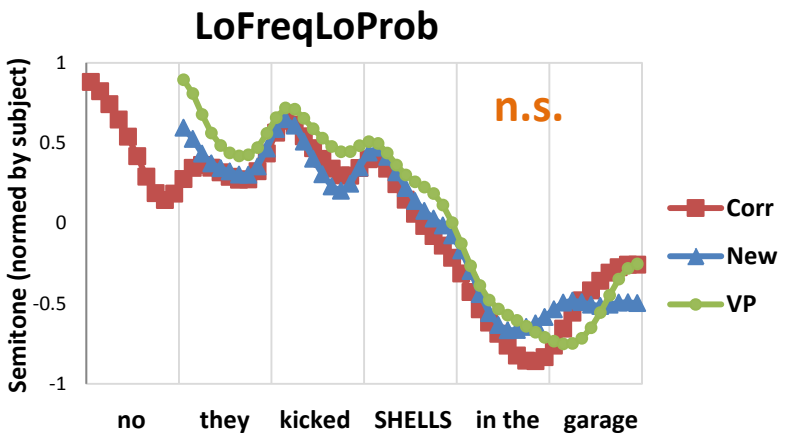
The roles of word frequency and contextual probability

Overall-Informativity Hypothesis = Information structure (IS) determines prosodic prominence, but IS effects are weak when another factor also demands emphasis

- **To what extent? Could IS effects disappear?**
- **In what way? Could word frequency and contextual probability have different impacts?**

PROSODIC PROMINENCE OF OBJ	Probable Context	Improbable Context
Frequent Word	**Strong effects of focus** • No other factor demands prosodic prominence • IS would play a key role	**Weak effects of focus** • Low-prob brings prominence • IS distinctions might be somewhat masked
Infrequent Word	**Weak effects of focus** • Low-freq brings prominence • IS distinctions might be somewhat masked	**Weakest/No effects of focus** • Two other sources of prosodic prominence • IS effects might disappear

Results

	Probable Context	Improbable Context
Freq Word		
Infreq Word		

Deeper dipping after Obj = More prominent Obj

Predictions revisited

	Probable Context	Improbable Context
Frequent Word	**Prediction: strong focus effect** **Result: CORR=NEW >> VP** • Both corrective and new-info focus add extra prominence to Obj.	**Prediction: weak focus effect** **Result: NEW >> CORR=VP** • Corrective focus does NOT add extra prominence to Obj, yet new-info focus does.
Infrequent Word	**Prediction: weak focus effect** **Result: CORR >> NEW=VP** • Only corrective focus adds extra prominence to Obj; new-info focus does NOT.	**Prediction: weakest/no effect** **Result: NEW=CORR=VP** • Neither corrective or new-info focus adds extra prominence to Obj.

‘Saturation effect’ in post-focus compression?

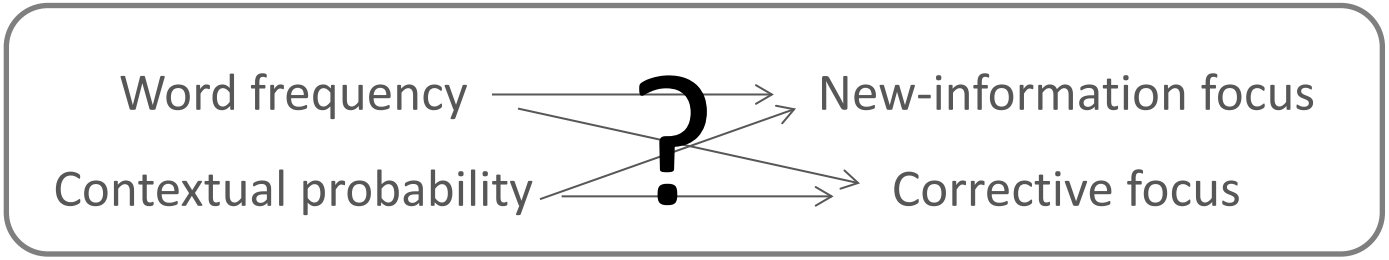
- Narrow focus (correction and new information) gives prominence to focused elements.
  - Post-focus pitch lowering is one way to prosodically encode this prominence.

- **Effects of narrow focus start disappearing when another factor also demands prosodic prominence** (when the focused element is an infrequent word or occurs in an improbable context).

- **Effects of narrow focus completely disappear when there are two other sources of prosodic prominence.**

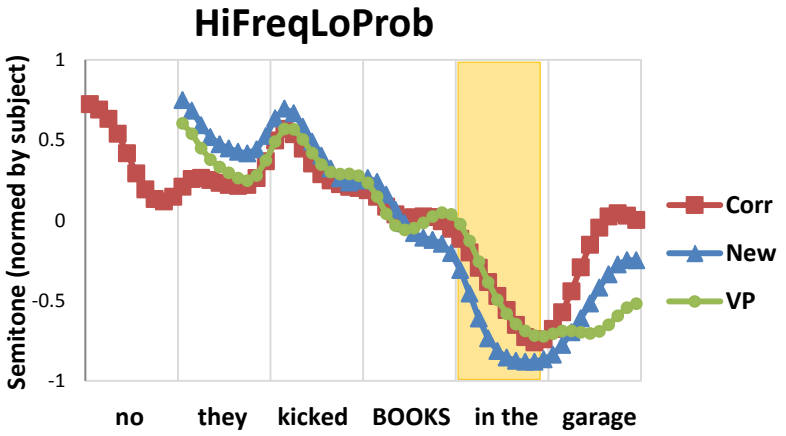
- Low word frequency and low contextual probability both mask the distinctions between different information-structural categories.
- Nevertheless, they don't **equally** impact all the information-structural categories.

What matters to whom?



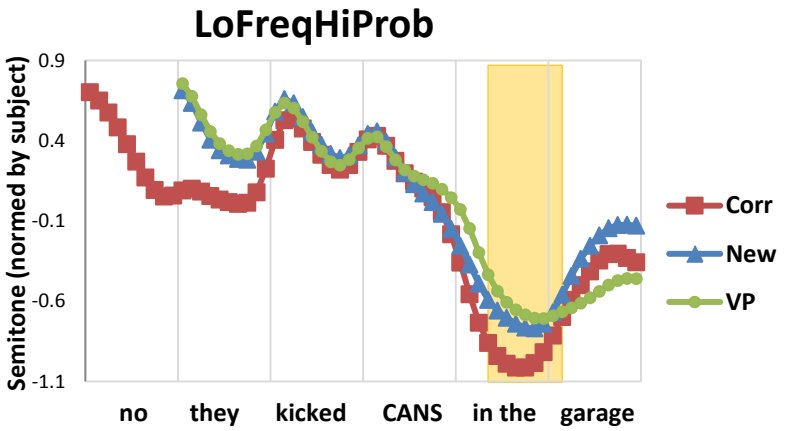
- **Corrective focus appears to be impacted more by contextual probability, whereas new-information focus seems to be impacted more by word frequency.**

Interaction between **information structure** and **contextual probability**



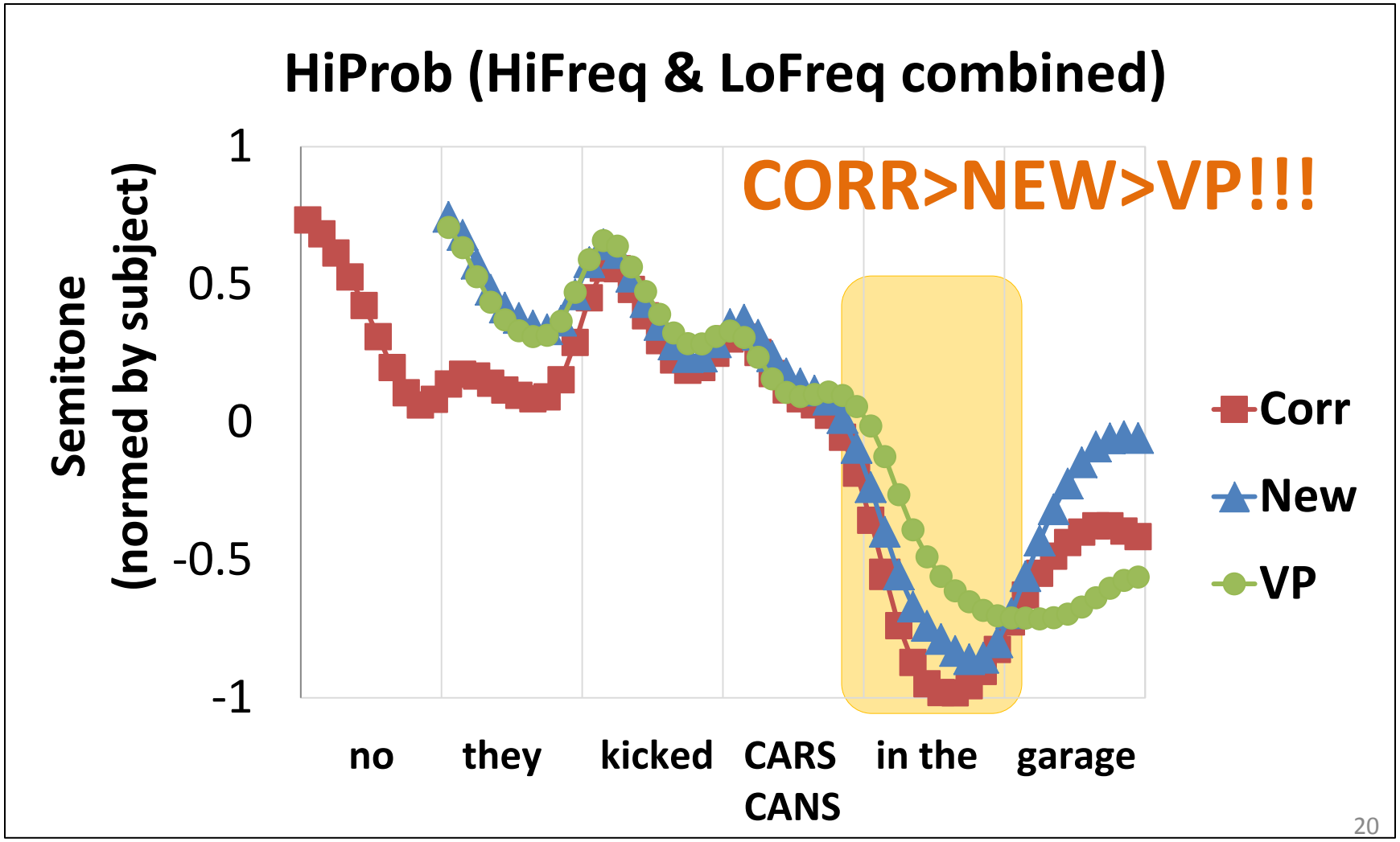
- In **low-probability contexts**, **corrective focus patterns with VP focus**.
- Seems to go against established knowledge:
  - correction => strong emphasis => high prominence
- In our study: corrective focus => correcting partner's incorrect belief
  - *I heard that Rita and Diane kicked dirt in the garage.*
  - *No, they kicked books in the garage.*
- **When the right information was contextually improbable, partner's mistake might not be so surprising/unexpected => less need for prominence in the correction?**
- Existing studies on focus types: mostly probable contexts

Interaction between **information structure** and **word frequency**



- For **low-frequency words**, **new-information focus patterns with VP focus**.
- In our study (and in general?), **infrequent words are more informative, conveying more specific, detailed information, so it might not be surprising/unexpected that the partner asked.**
  - *They kicked cans vs. cars in the garage.*
- **BUT**: Others have found that *words in narrow focus is more prominent than words in broad focus*
- Why? Existing studies mostly looked at probable contexts.

If this study hadn't included the low-probability-context conditions…



Interaction-based explanation

- Speakers think about the state of mind of the conversational partner
- **Prosodic profile of an utterance reflects speaker's expectation/surprise about what the other person has in mind**

- **Corrective focus** causes extra prosodic prominence when the other person shouldn't have been mistaken
  - Speaker is surprised by mistake (if high-probability word)

- **New-information focus** causes extra prosodic prominence when the other person could have inferred the object
  - Speaker thinks: Why is the other person asking about THAT?

What were individuals doing?

- Source of variability? Partly noise
  - Due to our experimental design (no repetitions, to ensure naturalness)

- Some key observations about different types of speakers
  - How individuals' prosodic styles might contribute to the main patterns

Related work on individual differences, for instance: Gagne, Masterson, Munhall, Bilida, & Querengesser (1994) and Ferguson (2004) on speech intelligibility; Koreman, Andreeva, Barry, Sikveland & van Dommelen (2008) and Niebuhr, D'Imperio, Fivela & Cangemi (2011) on pitch accents

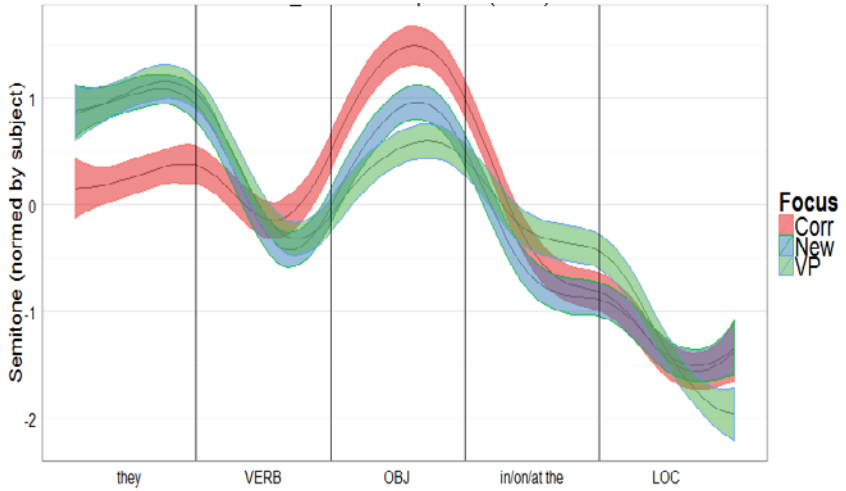
1. Pitch raising vs. lowering on Obj

Recall that we looked for prosodic signs of prominent Obj:

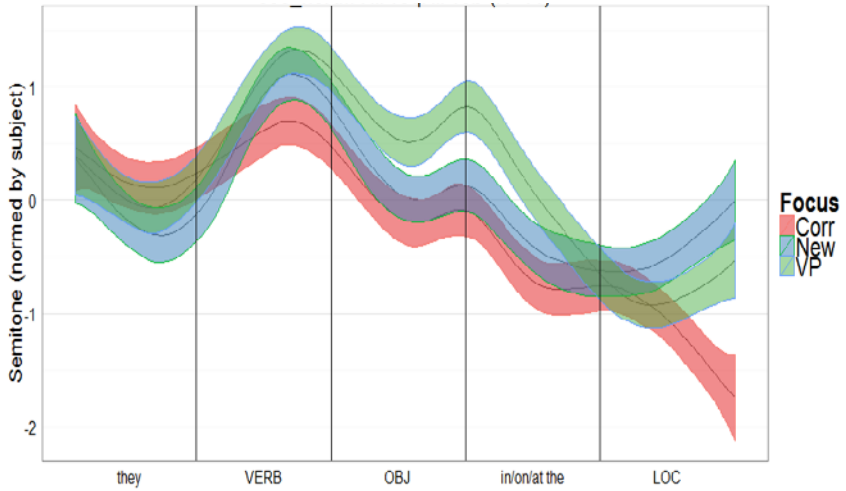
- **High pitch on Obj <= overall data showed nothing here?**
- **Low pitch right after Obj (= post-focus compression)**
  (e.g. Xu, Chen & Wang 2012)

- Individual patterns help explain this:
  - Some speakers marked prominence on objects by **raising** pitch
  - Other speakers marked prominence on objects by **lowering** pitch

Pitch raising in Obj for narrow focus (Subj 003)



Pitch lowering in Obj for narrow focus (Subj 010)



- May explain why main data set had no clear differences during Obj, and why post-focus compression turned out to be more robust

2. Highly sensitive vs. insensitive to word frequency and contextual probability

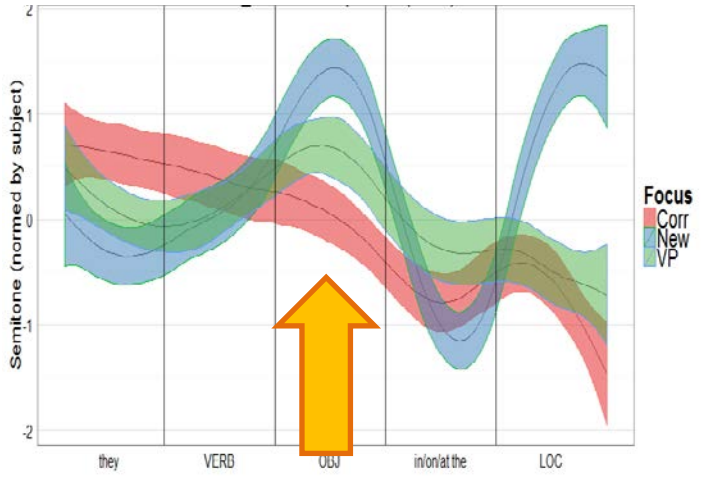
People differ in how sensitive they are to word frequency and contextual probability

- Some speakers distinguished between IS categories in all conditions: **highly insensitive to freq and prob**
- Some speakers distinguished between IS categories only in the high-freq high-prob condition: **highly sensitive to (low) freq and (low) prob**
- Some speakers showed interaction between focus and prob, but **no interaction between focus and freq**
- Some speakers showed interaction between focus and freq, but **no interaction between focus and prob**

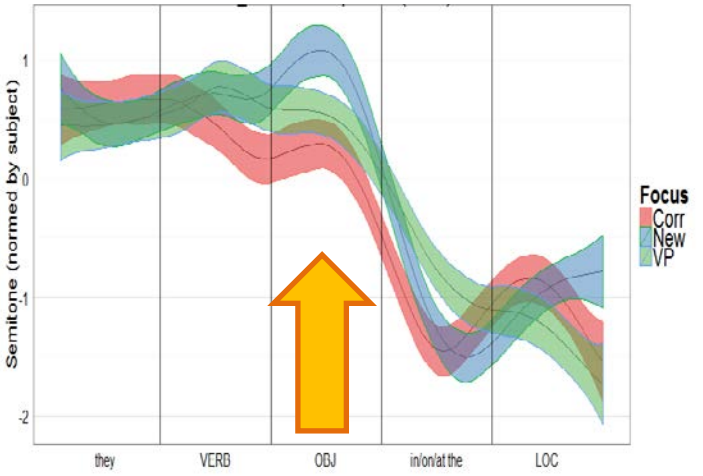
3. ‘Soft’ correction

- How forcefully do speakers correct?
  - Some speakers showed ‘anti-prominence’ in corrective sentences
  - Their pitch cues for corrective focus seemed to be even less prominent than VP focus

Subj 009



Subj 011



Politeness? We had similar findings on intensity in a prior study (Ouyang & Kaiser 2013)

Conclusions

- New insights gained by combining "information theory" and "information structure"
  - To understand how speakers encode focus types prosodically, we need to consider word frequency and contextual probability
- **Interaction-based explanation**:
  - Prosody reflects speaker's expectation/surprise about what the other person has in mind
- **Individual differences**
  - Further analyses are on-going
  - Current thoughts: Individual differences include variability in how sensitive people are to frequency and probability and how they mark prominence

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