Threshold adaptation and its time course

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The larger question

What principles govern decisions about **uncertain features of meaning** in a speech situation?

- This is a crucial part of the more general question of what factors determine the communicative content of our utterances.

- The empirical domain today: the interpretation of a particular class of context-dependent expressions: **gradable adjectives**.
Gradable predicates

- Gradable predicates are expressions that support orderings of objects in their domains relative to some scalar dimension, such as tall, happy, plain, etc.

- The meanings of gradable predicates are relativized to a threshold:

  - *two meters long* = \{x \mid x’s length = two meters\}

  - *longer than this pole* = \{x \mid x’s length > the length of this pole\}

  - *too long to fit in the truck* = \{x \mid x’s length > the maximum length that can fit in the truck\}
When the threshold is not made explicit, it is “determined by context:”

- \( \text{long} = \{ x \mid x \text{’s length} \geq \Theta_c \} \)

a. That pole is long (for a pole/garden object/thing).
b. That knife is long (for a knife/kitchen object/thing).
c. That rope is long (for a rope/garage object/thing).

(NB: #That rope is long for a pole.)
Threshold uncertainty

But even if the comparison class is known, the actual value of the threshold remains uncertain:

The guitar is big.
Scalar endpoint and fixed thresholds

The theater is empty.
Threshold uncertainty (due to context dependence) for gradable predicates with scalar endpoint

To the theater manager: “The theater was empty.”
To the homicide detective: “The theater was not empty.”
What information do language users recruit to resolve threshold uncertainty?

- Scalar structure encoded in the lexical semantics
  \textit{coordination on knowledge of language} (e.g. Kennedy, 2007; Leffel, Xiang & Kennedy, 2017)

- Distributional cues accrued from prior experience or present in the immediate local context
  \textit{coordination on beliefs about the world} (e.g. Lassiter & Goodman, 2014; Qing & Franke, 2014)

- Today’s talk: information about the interlocutor’s thresholds, listener-speaker alignment
  \textit{coordination on observations of participant behavior}
What information do language users recruit to resolve threshold uncertainty?

- Scalar structure encoded in the lexical semantics: *coordination on knowledge of language*

- Distributional cues accrued from prior experience or present in the immediate local context: *coordination on beliefs about the world*

- **Today’s talk**: information about the interlocutor’s thresholds, listener-speaker alignment
  *coordination on observations of participant behavior*
Descriptive vs. metalinguistic update

Barker (2002; 2013): Utterances involving gradable predicates provide information about the world and information about thresholds.

Mary asserts: “John is tall”

- Listeners infer that *Mary believes that*:
  i. $\theta_{\text{tall}} < \text{John’s height}$
Our question: Do decisions about gradable predicates thresholds also involve adaptation to other speakers’ thresholds?
Adaptation in the domain of speech perception

- Adaptation in speech perception is widely studied (e.g. to deal with talker variance)

- We adopted and modified an experimental paradigm from the speech adaptation studies in Kleinschmidt & Jaeger, 2015; Vroomen et al. 2007.
Adaptation in quantifier interpretation

Exposure phase: for a maximally ambiguous scene (13 /25 candies are green), a talker uttered “some/many of the candies are green”

Post-exposure phase: “How likely to you think it is that a/the speaker will describe this scene with each of these sentences?”

Yildirim et al., 2016
The current study examines:

- Adaptation for gradable predicates used in ambiguous scenes
- Adaptation for gradable predicates used in unambiguous scenes
- The time course of adaptation
- An exploration of the driving force behind the adaptation behavior
Stimuli

- bent bar
- plain pillow
- tall candle
In text: “Is this x tall/plain/bent?” YES/NO

* tokens from all 5 scale positions were presented multiple times, in a random order
* The most ambiguous scale position was determined for each individual subject separately, for each adjective.
PreCalibration

"Is this x tall/plain/bent" YES/NO

Exposure/testing

PostCalibration

Repeat the same procedure as the PreCalibration
Pre-calibration results
Exposure

24 trials total, each is a sound-image pair

Testing

* Testing trials appeared after the 2nd, 4th, 8th, 13th, 20th, 24th exposure trial.
* The most ambiguous image for each individual subject, together with the images from the neighboring scale positions served as the testing trials (separately tested)
Exposure

* The testing trials always presented the ambiguous image(s) and asked for judgments.

* The 24-trial exposure blocks varied based on the sound-image pairing. There are four different blocks (30 participants each block)

Prototypical. Positive
“This candle is **tall**”

Prototypical. Negative
“This candle is **not tall**”

Ambiguous. Positive
“This candle is **tall**”

Ambiguous. Negative
“This candle is **not tall**”
“Tall candle”: Comparing the post-calibration with the pre-calibration—**Ambiguous** exposure trials

**Pre-calibration**

**Exposure**

**Post-calibration**

**Post - Pre Difference**

- "not tall"
- "tall"
“Tall candle”: Comparing the post-calibration with the pre-calibration—Prototypical exposure trials

Hearers shift thresholds even when they have no conflict with the exposure statement.
A proposal for the hearer strategy (descriptively)

The hearer uses the speaker’s utterance to approximate the mean of the speaker threshold distribution, i.e. they shift the mean of the threshold distribution closer to where the observed exemplar is on a scale.

“This X is **tall**” triggers the hearer to shift the mean of the “**tall**” **threshold** closer to X

“This X is **not tall**” triggers the hearer to shift the mean of the “**Not tall**” **threshold** closer to X
Mary asserts: “John is tall”

-listeners infer that Mary believes that:

i. $\theta_{tall} < \text{John’s height}$

ii. $\theta_{tall}$ is relatively close to John’s height
Hearer Pre-exposure thresholds

$\theta$ for "not tall"  $\theta$ for "tall"

$tall = \{ x \mid x's \text{ height} > \theta_{tall} \}$

not tall = $\{ x \mid x's \text{ height} < \theta_{not \, tall} \}$
Speaker uttered: “X is tall”

Hearer Pre-exposure

θ for “not tall”  θ for “tall”

ambiguous token X

Speaker uttered: “X is tall”

the old ambiguous token X

Probability (X is tall)

X’s height > θ_{tall}

Hearer update
Hearer Pre-exposure

\( \theta \) for “not tall” \( \theta \) for “tall”

Speaker uttered: “X is tall”

Probability (\( X_2 \) is tall)

\( X_2 \)’s height > \( \theta_{\text{tall}} \)

Hearer update
Hearer Pre-exposure

$\theta$ for “not tall” $\theta$ for “tall”

ambiguous token $X$

Speaker uttered: “$X$ is not tall”

Probability ($X$ is tall)

$X_2$’s height $> \theta_{tall}$

Hearer update
Speaker uttered: “X is not tall”

Hearer Pre-exposure

*θ for “not tall”  θ for “tall”*

prototypical token X

```
X
```

```
X_2
```

Hearer update

```
the old ambiguous token X_2
```

```
X
```

```
X_2
```

Probability (X_2 is tall)

```
X2’s height > θ_{tall}
```

Hearer update
Adaptation effect for all three types of adjectives
The time course of incremental adaptation

![Graph showing the time course of incremental adaptation for different conditions.](image-url)
Summary of the adaptation behavior

• A hearer actively shifts his/her adjective threshold based on the speaker input. The estimated threshold distribution is assumed to have an expected value that is close to the observed data.

• Hearers’ threshold adaptation to the observed data happens very quickly, with as a little as two trials of exposure (could even be one). More exposure (higher frequency) did not increase the size of the effect.
• Is the adaptation behavior due to a low level strategy that blindly applies to any situations?
Exposure to non-human voice

Testing

- Yes
- No

Zarvox
Results for “tall candle”

- English speaker
- Synthesized speaker
- L2 speaker
Results for all three adjectives

- English speaker
- Synthesized speaker
- L2 speaker
“Non-agentive” Zarvox

Instruction before the exposure/testing phase starts:

“We are testing a speech synthesizer that can imitate human voice. In this section you will hear some verbal statements made by this synthesizer. Did you turn your speaker on?”
Exposure: no mention of a party

Testing:
- Yes
- No
Summery of the findings

- There is very rapid threshold adaptation based on inferences about the speaker’s threshold.

- Speaker-hearer alignment on threshold is not necessarily modulated by speaker identity (as indexed by different voices); but the hearer’s adaptation behavior is sensitive to the intentions/goals of the speaker.
Conclusions

• Multiple sources of information are recruited to resolve threshold uncertainty

  - Scalar structure encoded in the lexical semantics. *coordination on knowledge of language*

  - Distributional cues accrued from prior experience or present in the immediate local context. *coordination on beliefs about the world*

  - Information about the interlocutor’s intention and goals, and statistical strategies for speaker-hearer alignment. *coordination on observations of participant behavior*
Thank you!