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# Effects of speech rate on the intelligibility of non-native vowels

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# Introduction



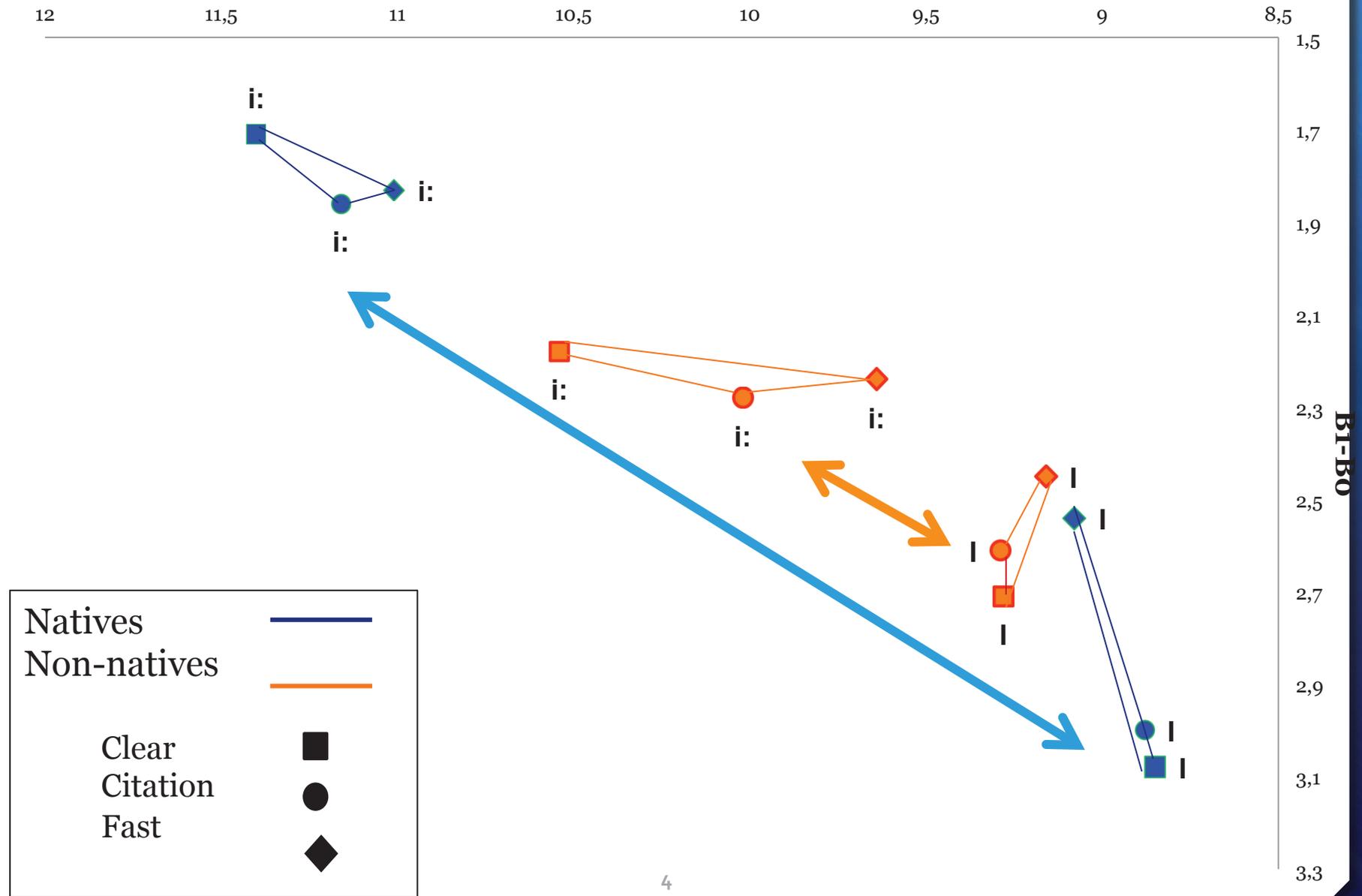
- **Speech is characterized by variability**
  - L2 learner requires additional attentional resources to attend to this contextual variation
  - Speech delivered at different rates
- **Speech rate effects on perception**
  - Adaptation to category boundary shifts caused by changes in speech rate (e.g. Flege & Schmidt, 1995; Miller & Volaitis, 1989)
- **Speech rate effects on production**
  - Slow speech and fast speech differ from each other (Lindblom, 1990; Johnson et al. 1993).
    - temporal dimension: shorter segments (VOT, vowels)
    - spectral dimension: centralized vs. dispersed vowels (Johnson et al., 1993; Johnson, 2000; Frieda et al., 2000; Moon & Lindblom, 1989)
    - L2 users (Kivistö- de Souza & Mora, 2012): 20 non-native speakers tested at three speech rates on the production of English /i:-I/.



# Vowel height and frontness

Kivistö-de Souza & Mora (2012)

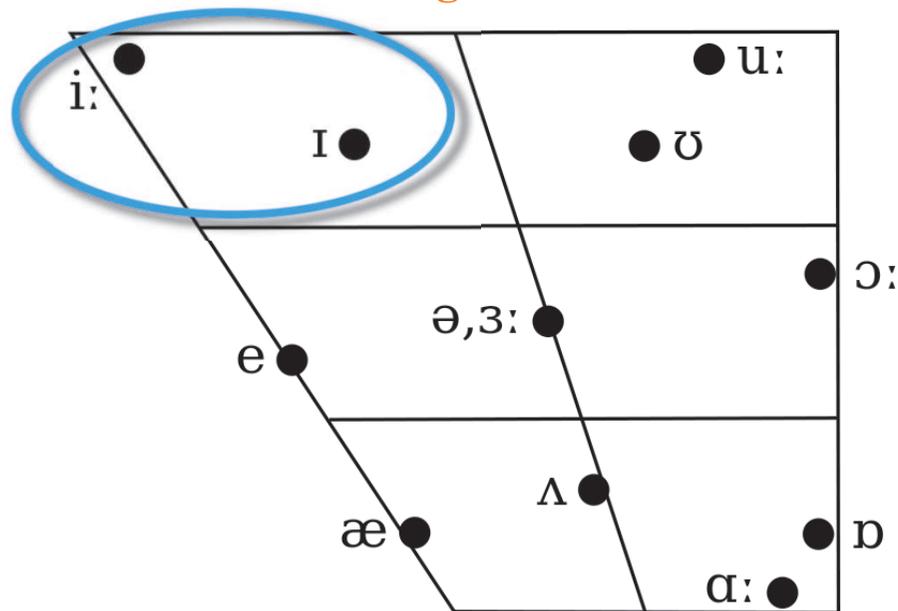
**B2-B1**



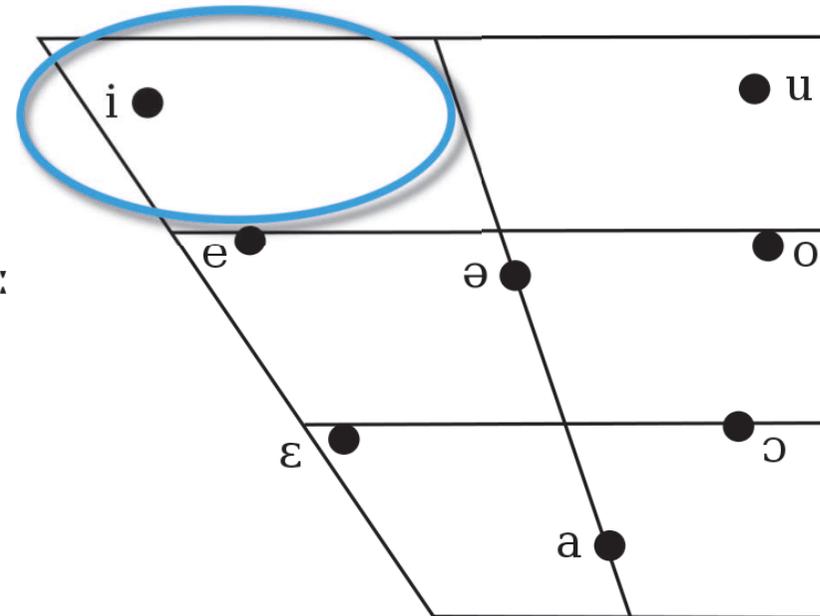
▪ **Vowel pair /i:/-/ɪ/**

- L1= Catalan/Spanish bilinguals :
  - /i/
  - smaller vowel inventories (5 & 7)
  - Spanish/Catalan learners distinguish the pair based on duration
    - Native speakers rely on spectral cues
    - Sp and Cat do not use temporal cues distinctively

**British English vowels**



**Catalan vowels**



# Present study



# Intelligibility of N and NN /i:/ - /ɪ/

- **EXPERIMENT I**

- Intelligibility of native speaker vowel productions at 3 speech rates by **non-native listeners**.

- **EXPERIMENT II**

- Intelligibility of non-native speaker vowel productions at 3 speech rates by **native listeners**.

# Research questions

## ■ EXPERIMENT I: Do changes in speech rate affect the perception of English /i:/ - /ɪ/ in non-native listeners?

- Hypothesis: Non-native listeners would have difficulties in perceiving the L2 vowels accurately due to incomplete category formation, and speech rate would pose additional difficulties.
- Non-native listeners may be relying on duration rather than spectral cues

## EXPERIMENT II: Do changes in speech rate affect the perception of English /i:/ - /ɪ/ in native listeners?

- **Hypothesis: The faster the speech rate the more difficult the identification of contrasting vowels because of their similar spectral values. At slower speech rates the identification should be easier because they are spectrally more distinct.**
- **Native listeners will rely mainly on spectral cues**

# Stimuli & Instrument

- 6 /i:/ - /ɪ/ minimal pairs :
  - *bead-bid; beat-bit; heed-hid; heat-hit; seed-Sid; seat-sit.*
- 3 Speech rates:
  - **Clear** (6.15 segments/seconds)
  - **Citation** (9.06 segments/seconds)
  - **Fast** (16.41 segments/seconds)
- Elicited through Delayed Sentence Repetition tasks from non-native and native speakers of English.
  - All speakers realized three different speech rates ( $p < .001$ )
- Presented through a forced choice identification task using pictures (prior a familiarization task)

# Research design

Experiment	Speakers	→ Stimuli	→ Listeners
I	Native speakers (n=5)	5 speakers x 12 target words x 3 speech rates = 180 items	<b>Non-native listeners (n=54)</b>
II	Non-native speakers (n=9) Native speakers (n=2)	11 speakers x 12 target words* x 3 speech rates = 346 items	<b>Native listeners (n=6)</b>

\* Some data missing from non-native speakers

# Experiment 1



L1	Catalan/Spanish
Sex	45 female, 9 male
Age	21.6 (SD= 5.2)
Daily use of English:	16.3% (SD= 9.1)



<b>Speakers</b>	<b>Stimuli</b>	<b>Listeners</b>
Native speakers (n=5)	5 speakers x 12 target words x 3 speech rates = 180 items	<b>Non-native listeners (n=54)</b>



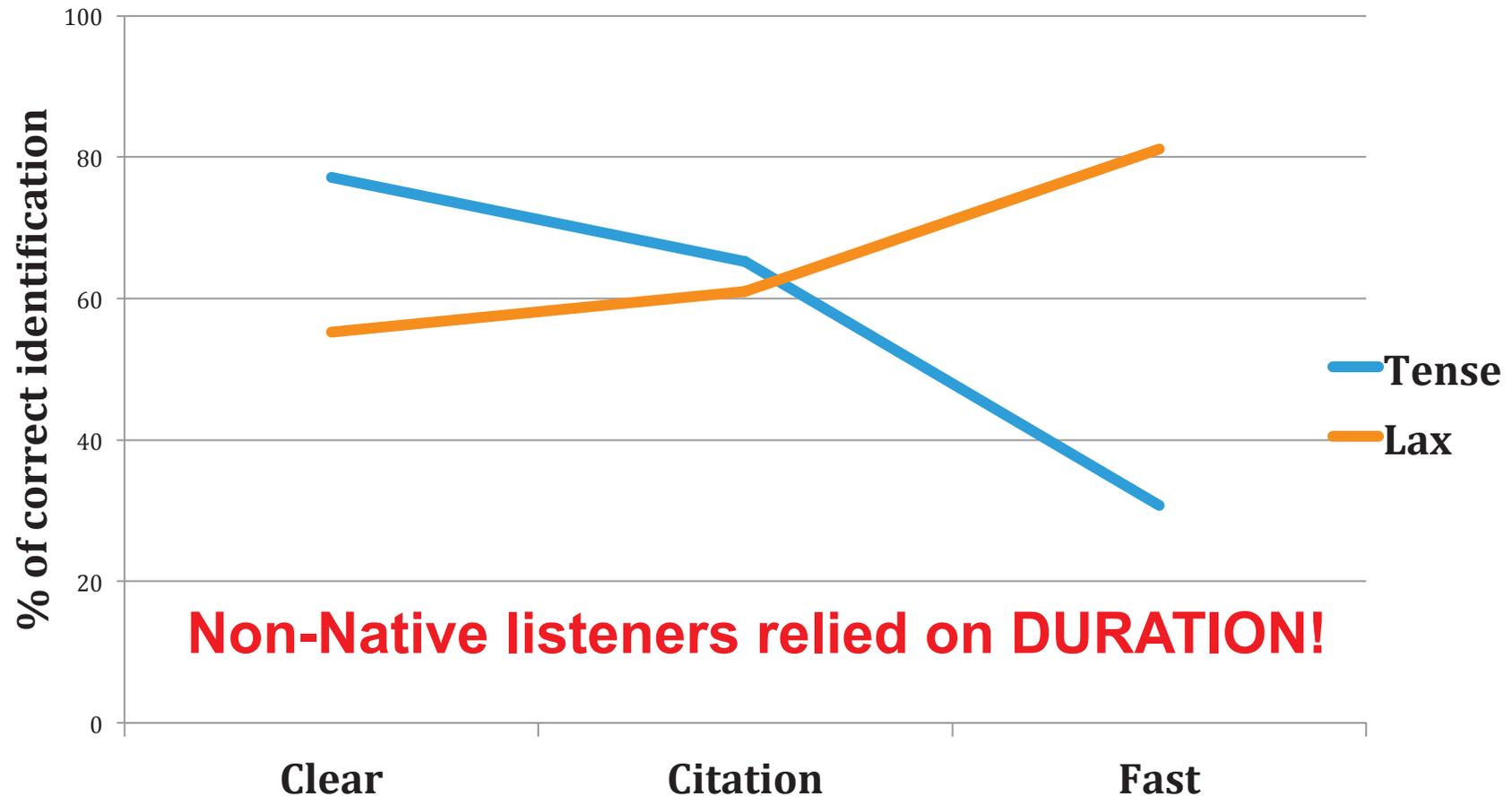
**Forced choice identification task**

# Descriptives

% of correct identification in non-native listeners

Vowel type	Speech rate	Native speakers
<b>Tense</b>	Clear	77.08 (14.8)
	Citation	65.20 (15.2)
	Fast	30.74 (17.0)
<b>Lax</b>	Clear	55.25 (19.0)
	Citation	60.99 (17.7)
	Fast	81.11 (14.2)

# Identification accuracy in non-native listeners



<b>ANOVA:</b>	speech rate (clear/citation/fast)	Sig. p<.001
	vowel quality (tense/lax)	Sig. p<.001
	speech rate x vowel quality	Sig. p<.001

# Experiment 2



L1	English (2Br, 4 Am)
Sex	(5 female, 1 male)
Age	30 (SD= 4.8)
Daily use of L2:	44.% (SD= 8.9)



Speakers	Stimuli	Listeners
Non-native speakers (n=9) Native speakers (n=2)	11 speakers x 12 target words* x 3 speech rates = 346 items	<b>Native listeners</b> (n=6)



**Forced choice identification task**

# Descriptives

% of correct identification in native listeners

Vowel type	Speech rate	Native speakers	Non-native speakers
<b>Tense</b>	Clear	97.22 (6.4)	72.22 (31.9)
	Citation	97.22 (6.48)	60.74 (36.4)
	Fast	97.22 (6.48)	52.22 (37.5)
<b>Lax</b>	Clear	94.44 (8.2)	70.65 (31.2)
	Citation	98.61 (4.81)	65.25 (36.5)
	Fast	94.44 (8.2)	69.20 (28.5)
<b>Combined</b>	Clear	95.83 (7.3)	71.43 (31.4)
	Citation	97.92 (5.6)	63.04 (36.3)
	Fast	95.83 (7.3)	60.81 (34.1)

◆ **Were native speaker vowels better identified than non-native speaker vowels?**

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Clear	$t(113)=6.73, p<.001^*$
Citation	$t(113) = 8.78, p<.001^*$
Fast	$t(113)=9.01, p<.001^*$

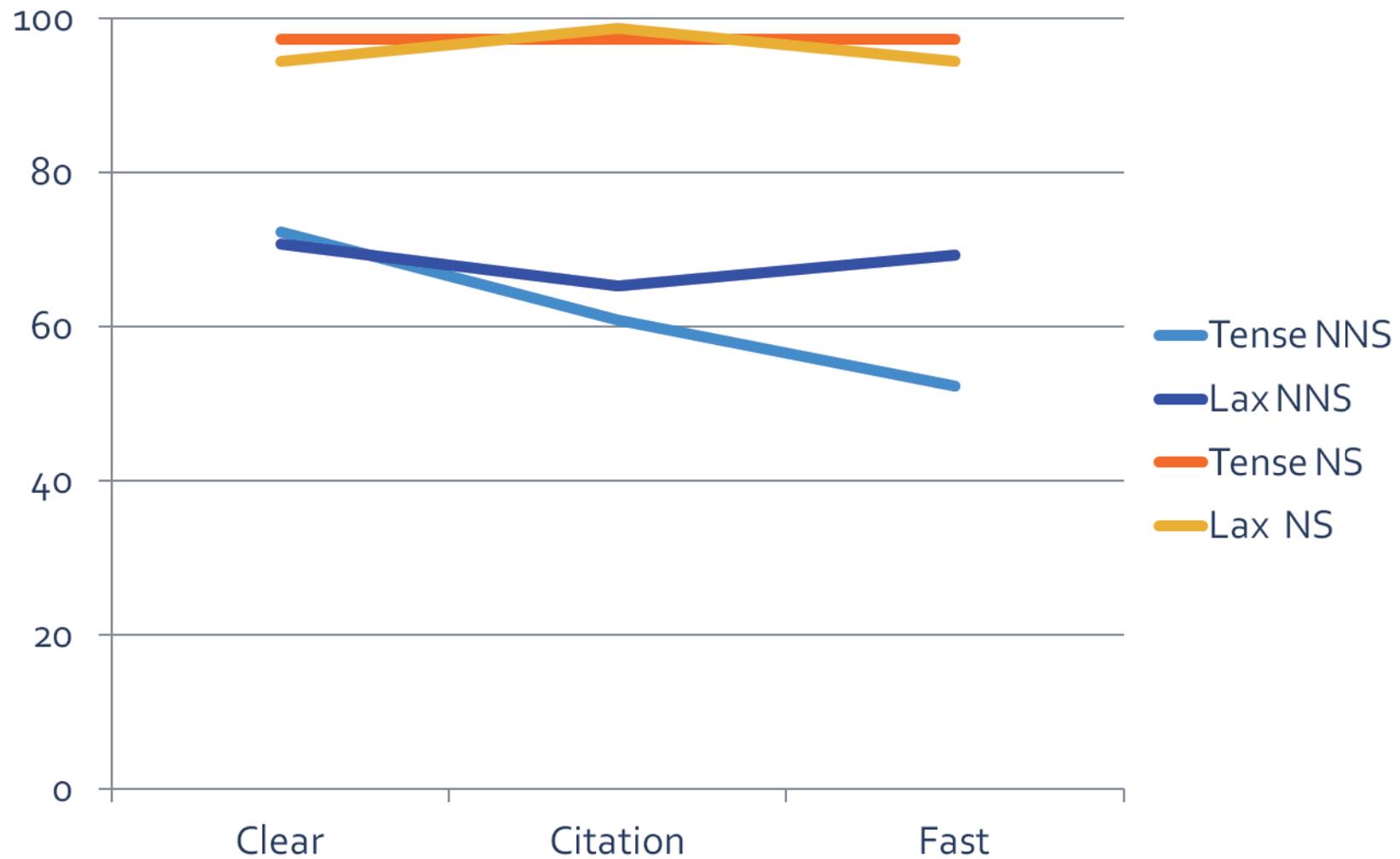
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◆ **Is the intelligibility of L2 vowels affected by speech rate?**

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	Anova
Speech rate	$F(2,88)=3.49; p=.035$
Vowel type (n.s)	$F(1,89)=1.64; p=.203$
Speech rate *Vowel type (n.s.)	$F(2,88)=2.35; p=.123$

# Identification accuracy in native listeners



# Conclusions



RQ 1 : Do changes in speech rate affect the accuracy of perception of English tense and lax high front vowels in non-native speakers?

➤ Yes: Speech rate affected the identification accuracy of the two vowels differently: The identification accuracy for the tense vowel became significantly worse when the speech rate increased, whereas the identification of the lax vowel became significantly more accurate when the speech rate increased.

➤ Ineffective cue-weighting strategies

RQ 2: Is the intelligibility of L2 vowels affected by speech rate?

➤ Yes: Our data revealed significant differences in intelligibility scores due to speech rate variation, mainly due to better identification of the tense vowel at the clear speech rate.

➤ A larger sample of listeners

➤ The overall intelligibility was rather low (71-60%)

# Limitations and further research

- Few native speakers in Experiment II
  - Replicate the study with more participants
- No data from non-native speakers on non-native vowels:
  - Interlanguage speech intelligibility benefit
- Further studies on using speech rate at perceptual training
  - Could perceiving and producing L2 speech at different rates lead to improved L2 phonological competence?

**Thank you for your attention!**