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The interaction between specificity and linguistic contrast

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Introduction

In our earlier experiment, subjects listened to words containing initial-p with lengthened VOT. Their imitation of the VOT was then tested by having them read three types of words: (a) the words they just heard, (b) another set of p-initial words, and (c) k-initial words. Subjects lengthened their VOT significantly, compared to baseline tokens recorded earlier in the experiment. Furthermore, the imitation was generalized to new instances of /p/ as well as to the new segment /k/.

The current study aims to further investigate how specificity interacts with linguistic representations, by testing whether the imitation effect is observed when the listening stimuli have shortened VOT, which could introduce linguistic ambiguity.

Do speakers imitate and generalize VOT even if the change might impair linguistic contrasts?

Background

- **Invariant/Prototype View** of Speech Perception
 - Linguistic representation is abstract and invariant = **prototype** (e.g., Halle, 1985)
 - No knowledge of individual tokens (exemplar)
- **Exemplar View** of Speech Perception
 - Each category is represented in memory by a large collection of remembered **exemplars** (e.g., Hintzman, 1986)
 - No knowledge of prototype

Background

- A key prediction of **exemplar-based** theories: **specificity effects**
- Specificity effects have been found in the:
Repetition Priming paradigm
 - **Already experienced tokens are processed faster than new ones:**
 - **Interpretation - Detailed information in the memory facilitates speech processing (e.g., Mullennix et al., 1989)**

Background

Specificity effects can also be tested in the:

Imitation paradigm

- **Subjects' speech is compared before and after they are exposed to target speech**
 - **Subjects shift their production in the direction of the target**
 - **Interpretation - Surface information in speech affects speech production**
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- **Goldinger** (1996, 1997, 1998) *voice & F0 in single-word shadowing, (2000) voice non-shadowing*
 - **Shockley et al.** (2004) *voice & VOT in single-word shadowing*

Background

■ Nielsen (2005):

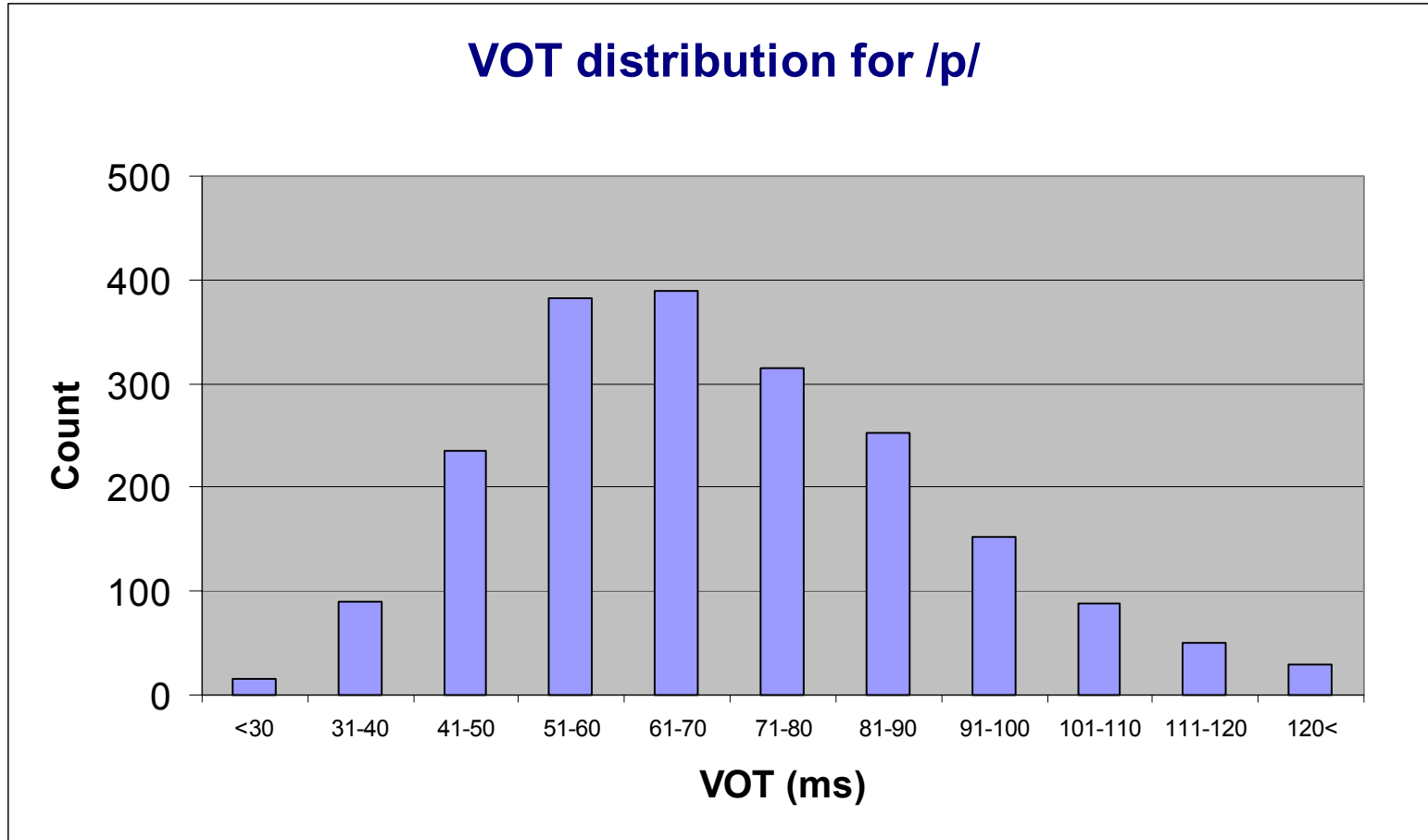
- Phonetic imitation of lengthened VOT on /p/ was found in **non-shadowing** paradigm
 - Key stimuli: Lengthened VOT
(+40ms from original, 113.26ms in average)
- The effect was **generalized** to new instances of /p/ as well as to the **new segment /k/** (which shares the same feature [+spread glottis]), indicating that the size of linguistic unit imitated is **sub-phonemic**
- Lexical frequency effect (predicted by Exemplar theories) was not observed (low frequency = less exemplar -> weight of one exemplar is relatively bigger)
- **Was the imitation caused by exemplars?**

Question

Do speakers imitate and generalize shorter VOT even if the change might impair linguistic contrasts?

- Very short VOT could cause confusion with voiced category (i.e., /b/), while there is no such danger for very long VOT
- **Strict exemplar view** predicts the same imitation effect for shortened VOT, because...
 - Each category is represented in memory by a large collection of remembered **exemplars** (e.g., Hintzman, 1986)
 - No knowledge of phonemic contrast
- Baseline recordings suggest that listeners are typically exposed to short VOT (<40ms) and long VOT (>100ms) equally often
 - Our baseline data show that subjects' distribution of VOT is normal, centering around 70ms (mean=69.4ms)

Question



**Data based on 20 subjects' baseline productions.
Each subject produced 100 /p/-initial words.**

More Questions

- Our earlier results showed that the imitation effect was **generalized** into new words that contain the same phoneme /p/ as well as the phoneme /k/, suggesting that the effect is based on listeners' knowledge of **features/natural classes**
- Can we observe the direct relationship between /p/ and /k/ quantitatively?

Goals

To investigate

- 1) the effect of phonetic imitation
- 2) generalizability of the effect to *new stimuli*
- 3) effect of *lexical frequency*

...using 2 types of stimuli:

(1)Lengthened, and (2)Shortened VOT

(+/- 40ms from original)

– Are they both imitated?

Methods

➤ Participants:

- 20 native speakers of American English (10M & 10F) with normal hearing and reading
- 10 in each group
- Received course credit for participating

Methods

Stimuli

- **Listening list** (for study-phase)
 - **80 target words with initial /p/ (with lengthened or shortened VOT)**
 - 40 filler words with initial sonorants
- **Production list** (for baseline and test phase)
 - **120 target words**
 - (1) the 80 modeled words (the targets in listening list)
 - (2) 20 new words, also with initial /p/
 - (3) 20 new words with initial /k/, which like /p/ is [+spread glottis]
 - 30 filler words with initial sonorants

Methods

Stimuli (continued)

- **Lexical frequency:**

- **40 of the target words had high frequency, and 40 had low. All the new words had low frequency**

Kučera & Francis, (1967) Hi>50, Low<5

CELEX2 (Baayen, Piepenbrock and Gulikers, 1996) Hi>1000, Low<300

- **Phonological neighborhood density & number of syllables** were controlled across frequency groups

(Neighborhood density obtained from Sommers 2004)

- **Familiarity:**

- 6.0-7.0 on the 7-point Hoosier Mental Lexicon scale

(Nusbaum et al., 1984)

- **All the target words had initial stress, no onset clusters**

Methods

- A phonetically trained male American English speaker recorded the 120 words in the listening list
- The speaker produced all the words normally, and the target words *with extra aspiration*
- The VOT for the normally produced initial /p/ was:
 - Lengthened** by 40ms (for **Group 1**)
 - Spliced with the initial part of hyper-aspirated tokens to preserve natural formant transitions
 - The resulting tokens had average VOT of 113.26 ms (SD=10.82ms)
 - Shortened** by 40ms (for **Group 2**)
 - The most stable part of aspiration was taken out
 - The resulting tokens had average VOT of 32.29ms (SD=12.39ms)

Procedure

The experiment used a slightly modified version of the imitation paradigm from Goldinger & Shockley et al. (A warm-up silent reading phase was added at the beginning to avoid possible hyper-articulation)

1. **Warm-up Phase:** Subjects read the production list silently
2. **Baseline (Pre-study) Phase:** Subjects read the production list aloud
3. **Study Phase:** Subjects listened to the listening list (no other task)
4. **Test (Post-study) Phase:** Same as the Baseline Phase above

Results

Group 1: Lengthened VOT

- Significant difference between pre- and post-study phase production (pre < post) across all types of stimuli = **Imitation effect**
- No lexical frequency effect
- **Heard items showed significantly stronger effect** than unheard items

Results

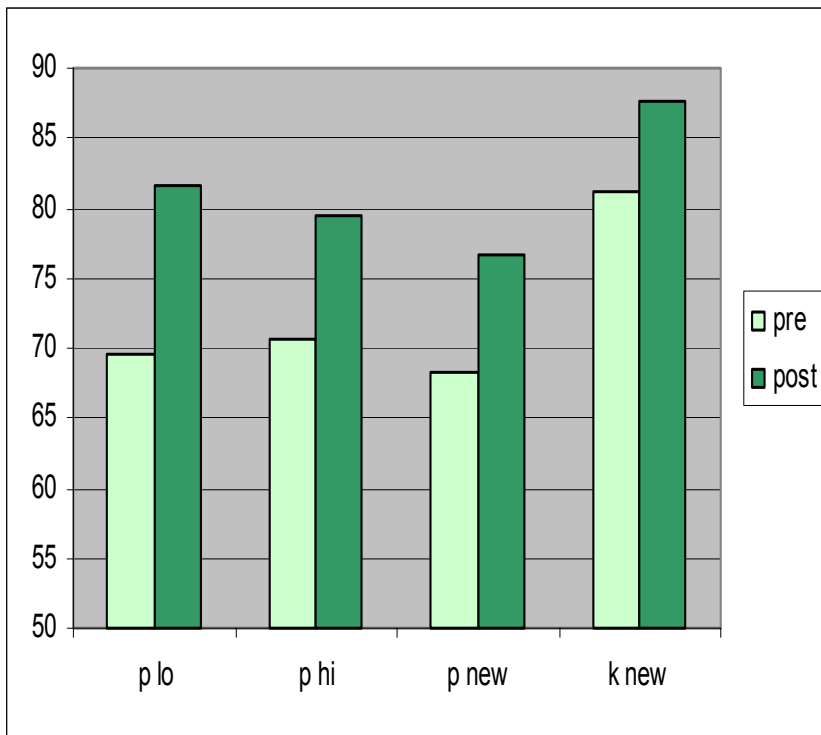
Group 2: Shortened VOT

- No significant difference between pre- and post-study phase production (pre = post) across all types of stimuli = **No imitation effect**
- No lexical frequency effect
- No significant difference between “heard” items and unheard items

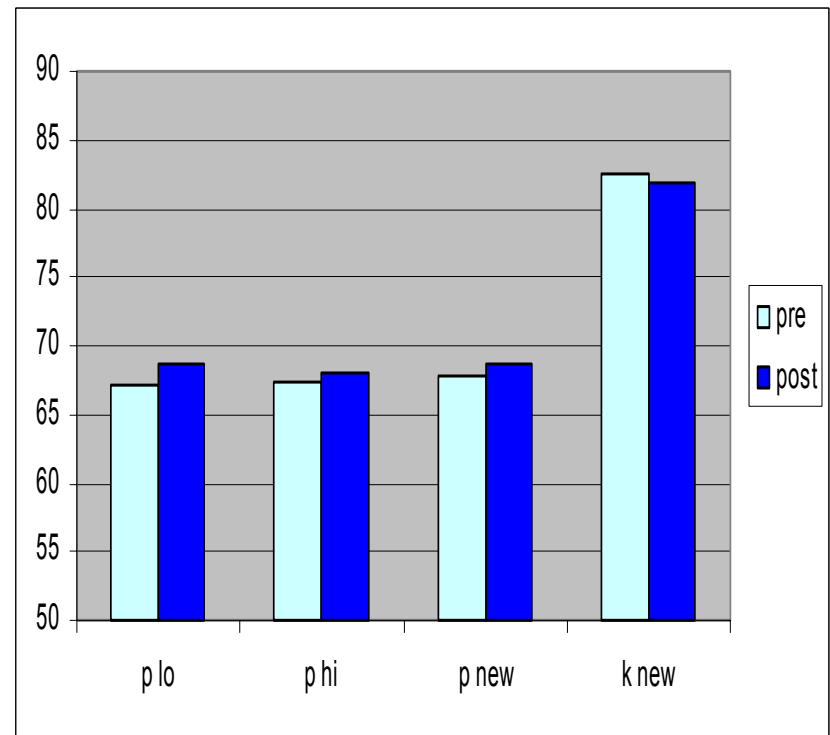
Results

Significant difference between the groups (the amount of imitation): $F(1,18) = 4.498, p < .05^*$

Group 1 (Expect longer VOT post)



Group 2 (Expect shorter VOT post)



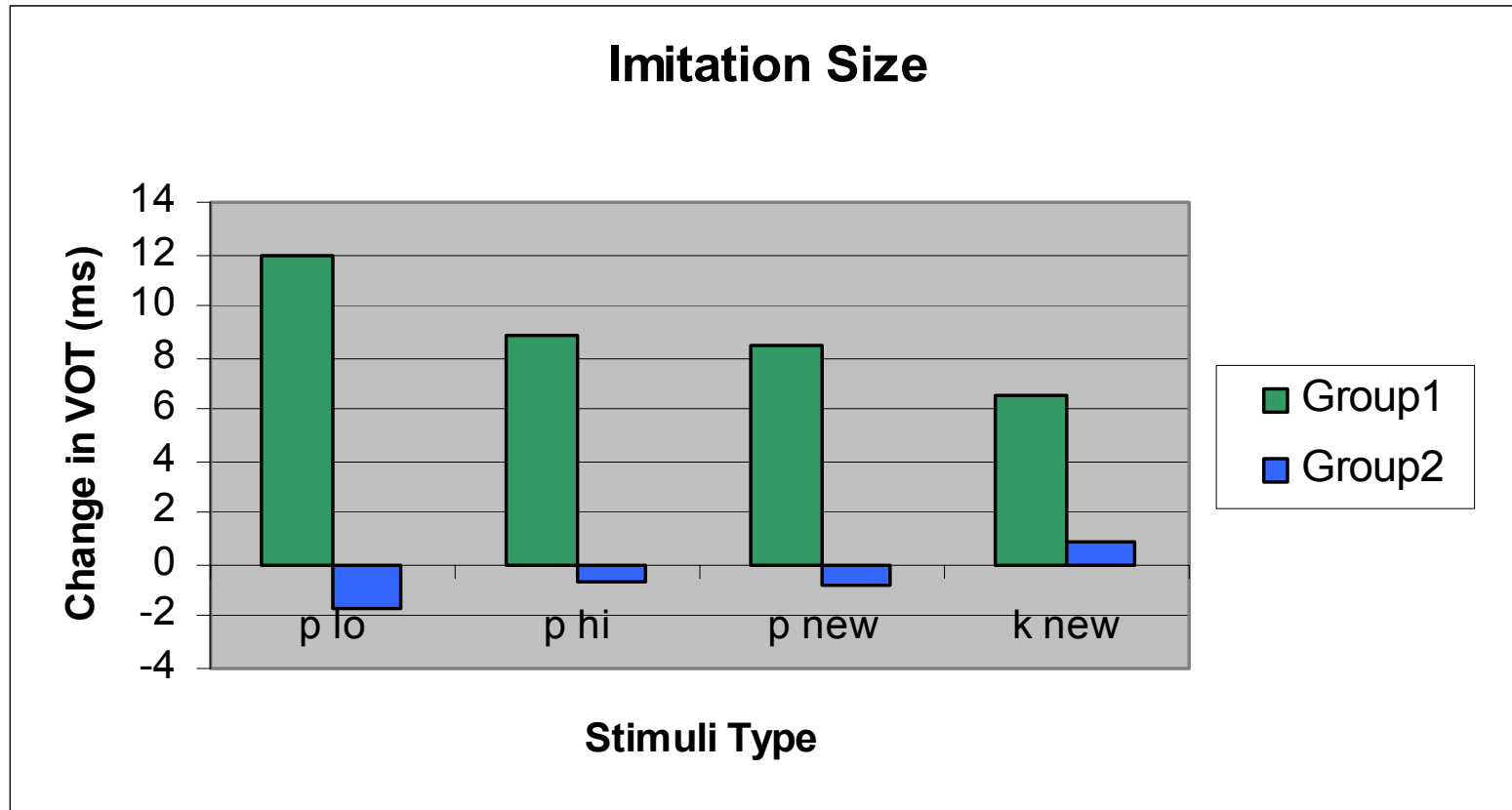
Results

Repeated Measure ANOVA

	Group1	Group2
pre vs. post lexical frequency Interaction	F(1,9)= 6.771, $p<.05^*$ F<1, $p>.1$ F<1, $p>.1$	F<1, $p>.1$ F<1, $p>.1$ F(1,9)=1.444, $p>.1$
pre vs. post heard vs. unheard Interaction	F(1,9)=7.843, $p<.05^*$ F(1,9)=6.551, $p<.05^*$ F<1, $p>.1$	F(1,9)=1.172, $p>.1$ F<1, $p>.1$ F<1, $p>.1$
pre vs. post segments Interaction	F(1,9)=9.037, $p<.05^*$ F(1,9)=161.87, $p<.001^*$ F<1, $p>.1$	F<1, $p>.1$ F(1,9)=34.281, $p<.001^*$ F<1, $p>.1$

Results

- Comparison of Imitation Size:



Group1: post – pre study phase VOT

Group2: pre – post study phase VOT

Results

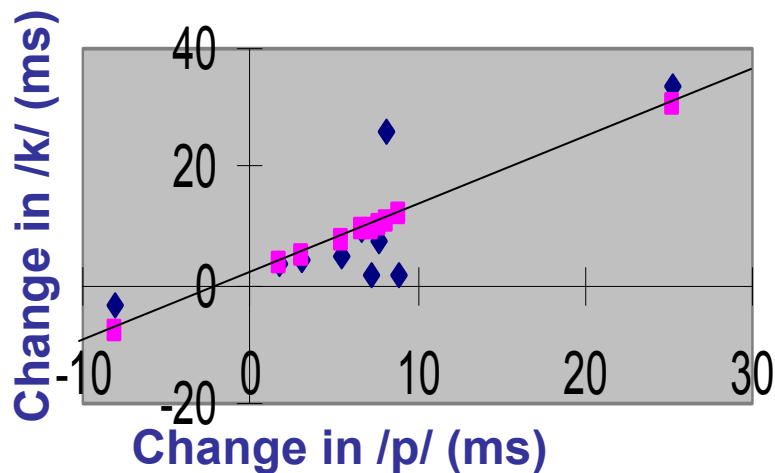
- Significant correlation between /p/ and /k/ with individual subjects:

- The correlation was stronger for **Group1**

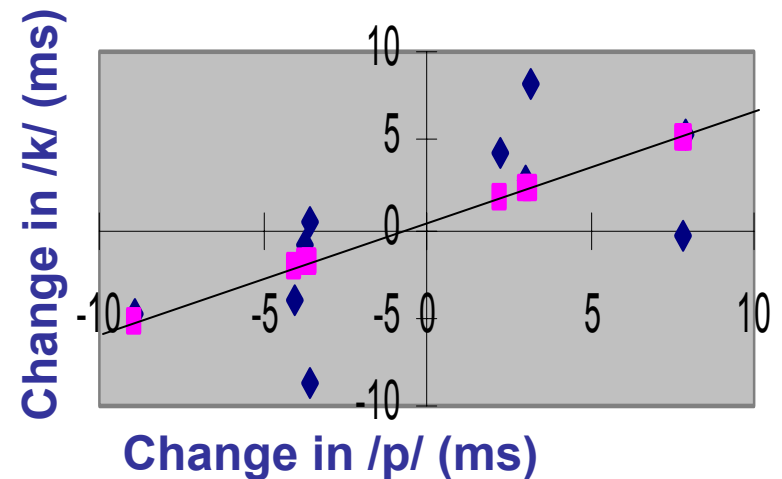
Group1: $r=.80$, $(F(1,9) = 14.50, \text{Sig}<.01)$

Group2: $r=.67$, $(F(1,9) = 6.63, \text{Sig}<.05)$

Line Fit Plot / Group 1



Line Fit Plot / Group 2



Discussion

The imitation effect was generalized to new words containing /p/ as well as words containing /k/. The correlation between /p/ and /k/ was strong regardless speakers lengthened or shortened VOT

- Suggests psychological reality of **sub-phonemic representations**

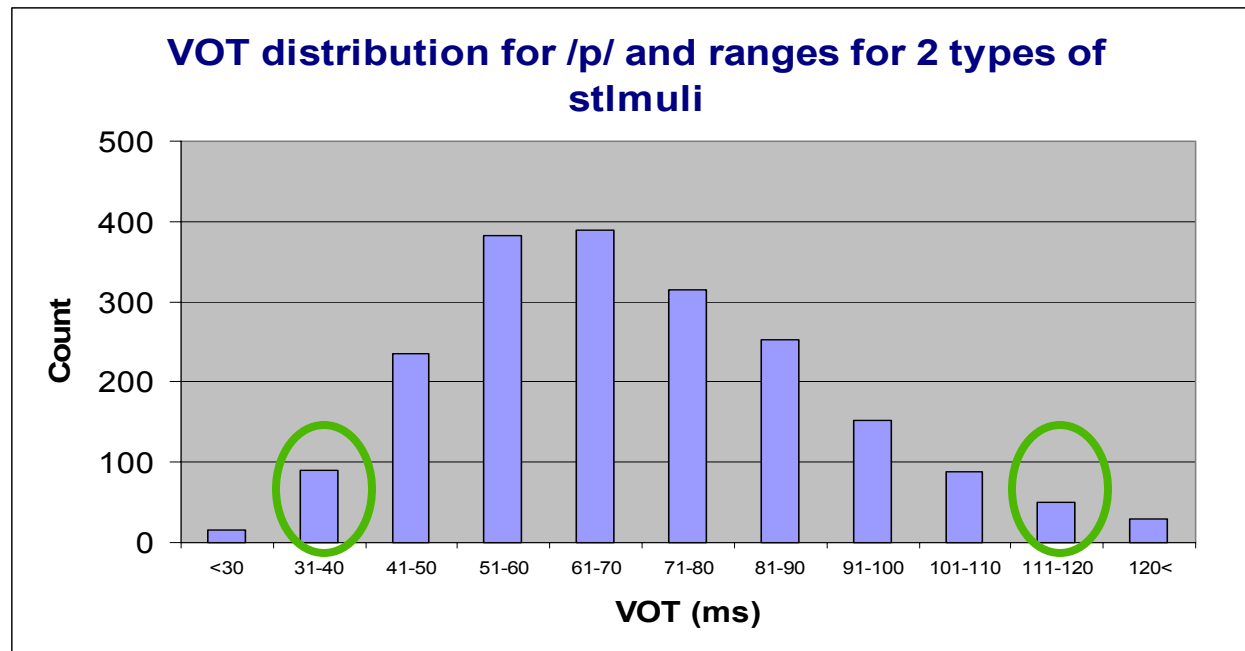
(For Group1) stronger imitation effect for actually heard items than unheard items

- Suggests **word-specific advantage** (exemplar)
- Do productions reflect both exemplars and the grammar?

Discussion

Subjects imitated long VOT, but did not imitate short VOT (despite the fact that based on the baseline recordings, shorter VOT occurs more often than longer VOT)

- Knowledge of **linguistic structure (phonemic contrast) influences our production**



Conclusion

This study showed that...

- (1) Phonetic generalization can apply at a sub-phonemic level**
- (2) Phonetic imitation does not occur when it would impair a phonemic contrast**

References

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