IMPLICIT PHONETIC IMITATION IS CONSTRAINED BY PHONEMIC CONTRAST

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Introduction

The imitation paradigm (Goldinger,1998) has shown that subjects shift their production in the direction of the target, indicating the use of *episodic traces* in speech perception and production. By extending the paradigm to *non-shadowing*, the current study aims to test: 1) if/how this implicit phonetic imitation interacts with linguistic representations when the change might impair linguistic contrast; 2) whether phonetic imitation can be *generalized*, and 3) whether word-level specificity can be obtained through physical measurements of a phonetic feature.

Questions

1. Would the imitation effect be observed when a shift in production would impair a linguistic contrast?

Very short VOT of /p/ introduces linguistic ambiguity (confusion with voiced /b/), while there is no such danger for very long VOT. An extreme episodic view predicts the same imitation whether or not it endangers a contrast

2. Can phonetic imitation effect generalize to sub-lexical and/or sub-phonemic representations?

For example, /p/ and / k/ share the same acoustic cue "Long VOT". Listeners' knowledge of linguistic structure allows (and predicts) sub-phonemic generalization from heard /p/ to unheard /p/ and /k/

3. Is there a word-specific advantage in phonetic imitation?

An episodic view predicts a stronger specificity for 1) more recently experienced words, and 2) low-frequency words (Low frequency = fewer exemplars → weight of one exemplar is relatively larger)

1. **Effect of linguistic contrast**
   (key stimuli: Long vs. Short VOT)
2. **Generalizability of the effect to *new linguistic units***
   (phoneme, feature)
3. ***Effect of word specificity in VOT imitation effect***
   (high vs. low freq, target vs. novel item)

Methods

Participants:

46 native speakers of American English (22M & 24F): 27 in Group1 (long VOT) and 19 in Group 2 (short VOT)

Stimuli

Listening list [120 words] (for listening phase)
- **80 target words with initial /p/ with manipulated VOT**
- 40 filler words with initial sonorants

Production list [150 words] (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

Lexical frequency:
40 of the target words had high frequency, and 40 had low. (Kučera & Francis (1967) Hi>50, Low<5: CELEX2 (Baayen, Piepenbrock and Gulikers, 1996) Hi>1000, Low<300)
All new words had low frequency

Phonological neighborhood density & number of syllables: Controlled between frequency groups
(Neighborhood density: from Sommers 2004)

Familiarity: 6.0-7.0 on the 7-point Hoosier Mental Lexicon scale (Nusbaum et al., 1984)

All target words had initial stress, no onset clusters

- A phonetically trained male American English speaker recorded the 120 words in the listening list
- The speaker produced: 1) All the words normally, and 2) 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
➔ average VOT = **113.26 ms** (SD=10.82ms)

Shortened by 40ms (for **Group 2**)
The most stable part of aspiration was taken out:
➔ average VOT = **32.29ms** (SD=12.39ms)

Procedure

The experiment used a slightly modified version of the imitation paradigm from Goldinger(1998). The participants first read the list silently (warm-up phase), to help avoid possible hyper-articulation found in our pilot

1. **Warm-up**: Subjects read the production list *silently*
2. **Baseline**: Subjects produced (read) the production list aloud
3. **Listening**: Subjects heard the listening list (no other task)
4. **Test**: Same as the Baseline Phase

The subjects' tokens were digitally recorded and VOTs were measured using both waveforms and spectrograms.

Results & Discussion

Between group factor:
Listening Stimuli (Long vs. Short VOT)

Within group factors:
Type of Production (Baseline vs. Test)
Lexical Frequency (High vs. Low)
Word Specificity (Target vs. Novel Items)
Imitated Unit (/p/ vs. /k/)

➢**Significant interaction between Type of Production x Listening Stimuli** (*p* <.001*)
= Group Difference

Group1 (Lengthened VOT)

Significant Main Effects on:

➢ **Imitation** (Baseline vs. Test) Longer VOT in the Test phase for *all types of stimuli* (*p* <.005*)
= Generalization

Lexical Frequency (High vs. Low)
Longer VOTs for Low freq (*p* <.05*)

Word-Specificity (target vs. novel)
Longer VOTs for Target (*p* <.01*)

Imitated Unit (/p/ vs. /k/)
Longer VOTs for /k/ (*p* <.01*)

➢ **However, no interactions** of Imitation with other factors**:** Lexical Frequency, Word-Specificity, Imitated Unit

Group 2: (Shortened VOT)

➢ No significant difference between Baseline and Test production across all types of stimuli (*p* >.1)
= No imitation effect

➢Clear lexical frequency effects in Goldinger (1998): Why not in our data?

Post-hoc analysis:

➢Subjects whose baseline/test difference was greater than 5% (16 out of 27 in Group1)
(some subjects showed no imitation at all, confounding possible effects)

➢**Significant interaction between Imitation and Lexical Frequency** (*p* <.05*)
= Frequency Effect on Phonetic Imitation

➢Also, marginal word-specificity effect (Target vs. Novel Items) (*p* =.054)

➢No effect of Imitated Unit (/p/ vs. /k/) (*p* >.1)

Figure 1: Group1 Imitation effect plotted across four types of stimuli (listened to stimuli with LONGER VOT)

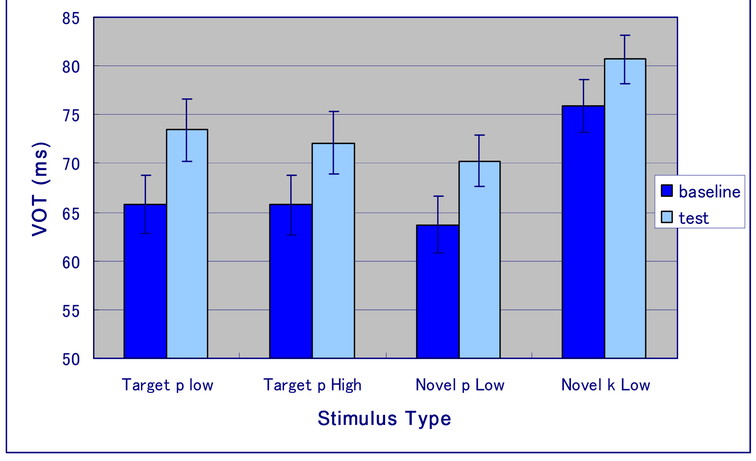
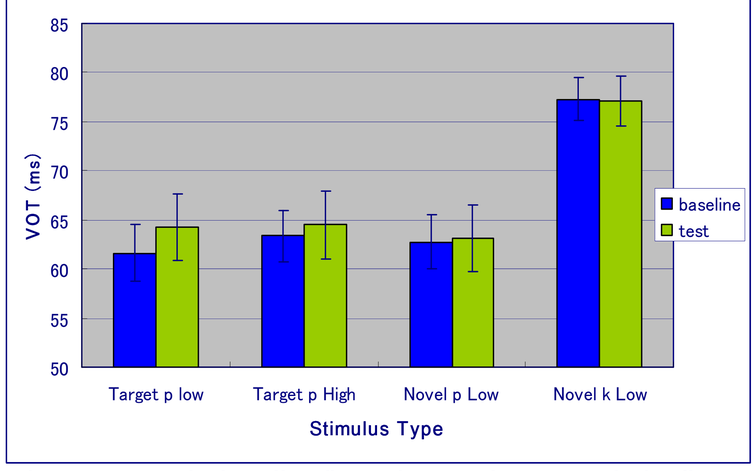


Figure2: Group2 Imitation effect plotted across four types of stimuli (listened to stimuli with SHORTER VOT)



Figures 1 & 2: Imitation effect (in VOT) across four types of stimuli
From left: (1) target words (initial /p/) with low frequency, (2) target words (initial /p/) with high frequency, (3) new words (initial /p/) with low frequency, and (4) new words (initial /k/) with low frequency

➢Subjects imitated long VOT, but did not imitate short VOT

➔**Knowledge of linguistic contrast modulates phonetic imitation**
Similar asymmetrical results in VOT Goodness Rating (Allen & Miller, 2001)

➢ The imitation effect was **generalized** to:
- **New words** which share the initial phoneme /p/
- **New phoneme /k/** which shares a feature [+spread glottis] (and: [-continuant, -sonorant, -voice]) = ***natural class***

➔**Support for sub-phonemic representation**

➢(For the subjects who showed a clear imitation effect,) words with low frequency showed stronger imitation effect than words with high frequency (**frequency effect**), as predicted by the exemplar view

➔**Support for word-level representation**

Conclusions

This study showed:

➢Speakers' sensitivities to linguistic structures:
Phonemic Contrast and
Sub-phonemic Representation

➢Also, some predictions of the extreme exemplar view were confirmed:
Phonetic Imitation and **Word-level Specificity (Lexical Frequency Effect)**

The results call for a linguistically informed exemplar model of speech perception and production, which incorporates both **sub-phonemic and word-level representations** as well as knowledge of **linguistic contrast**