The production-perception relationship in a language with multiple grammars

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We know that perception is influenced by NL restrictions

• [r]-[l] continuum perceived as 2 categories by English speakers, as 1 by Japanese speakers (Miyawaki et al. 1975).

• Ambiguous [r...l] perceived as [r] after [t], as [l] after [s] by English speakers (Massaro & Cohen 1983).

• Illegal CC perceived as CVC by Japanese speakers (e.g. *ebzo* as *ebuzo*) (Dupoux et al. 1999).
Perception-production connection

There is a relationship between the native language *production grammar* (mapping from lexical representations to phonetic representations) and *perception grammar* (mapping from acoustic signal to phonological representations).

(e.g., Smolensky 1966, Boersma 1998, 2011, Boersma & Hamann 2009, etc.)
Question of this talk

What if a single native language contains distinct grammars (tied to different lexical strata), with distinct sets of contrasts and phonotactic restrictions?

Will speakers use distinct perceptual strategies for different lexical strata?

<table>
<thead>
<tr>
<th></th>
<th>Singleton [p]</th>
<th>Voiced geminate obstruent</th>
<th>Nasal-voiceless stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yamato</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Sino-Japanese</td>
<td>no</td>
<td>no</td>
<td>yes (sampo ‘walk’)</td>
</tr>
<tr>
<td>Foreign</td>
<td>yes (peepaa ‘paper’)</td>
<td>yes (bedo ‘bed’)</td>
<td>yes (tento ‘tent’)</td>
</tr>
</tbody>
</table>
The Japanese lexicon consists of different lexical strata.

Each stratum is associated with a different production grammar.

The ranking of markedness constraints is invariant across all strata; only faithfulness constraints may be differently ranked.
Is perception sensitive to lexical stratum membership?
Moreton & Amano 1999: Cues to stratum affect perception

- [aa]# is possible **only in foreign stratum**.
- J speakers asked to identify nonwords *CoC[a...aa]* as *CoCa* or *CoCaa*.
- Cs provided cues to stratum membership.

<table>
<thead>
<tr>
<th>Contextual cues</th>
<th>[p], [φa]</th>
<th>[rj], [hj]</th>
<th>[t], [r]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Foreign</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>
Results

Ambiguous [a...aa] was more likely to be categorized as

- short in Sino-Japanese cue context (*[aa]).
- long in foreign cue context (where [a]-[aa] contrast is possible).

→ Contextual cues to stratum affiliation affected position of category boundaries.
Next question

Could knowledge of stratum membership alone affect category boundaries (in the absence of overt phonological cues to stratal affiliation)?
ambiguous stimuli created by lengthening final [a] or voiced stop in real words (e.g., mos[a...aa])

forced choice: mosa or mosaa).

<table>
<thead>
<tr>
<th></th>
<th>Real word</th>
<th>Nonword</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native</td>
<td>mosa ‘tough guy’</td>
<td>*mosaa</td>
</tr>
<tr>
<td></td>
<td>togu ‘sharpen’</td>
<td>*toggu</td>
</tr>
<tr>
<td>*[aa]#, *[gg]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foreign</td>
<td>nasa ‘NASA’</td>
<td>nasaa</td>
</tr>
<tr>
<td></td>
<td>magu ‘mug’</td>
<td>maggu</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results

Ambiguous [a...aa] and [g...gg] more likely to be categorized as

- **short** in words of **native** origin (*[aa]#, *[gg]).
- **long** in words of **foreign** origin (where short/long contrasts are possible).

→ Knowledge of stratum affected position of category boundaries, even in the absence of overt phonological cues to stratum affiliation.
Cues to stratal affiliation affect categorization, suggesting that speakers may use different perceptual strategies for different strata.

Can cues to stratal affiliation also affect the ability to discriminate contrast?
Contrasts of interest: *si/shi* and *ti/chi*

Itô & Mester 1995, 1999; Crawford 2007, 2008: possibility of contrast determined by stratum

<table>
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<tr>
<th>Possible contrast?</th>
<th><em>si vs. shi</em> ((sh \text{ for E } [ʃ], J [ɕ]))</th>
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<td>Native</td>
<td>no ((kas+i &gt; kashi \text{ ‘a loan’}))</td>
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<td>no ((shitibaNku \text{ ‘Citibank’}))</td>
<td>yes ((shitibaNku \text{ ‘Citibank’}))</td>
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Crawford 2007: “words first attested before about 1890 usually show the TI -> ČI adaptation pattern, while words first attested after about 1930 usually show the TI -> TI adaptation pattern instead...”

Although Japanese speakers were exposed to both si and ti, only ti became established.
Co-phonologies with distinct rankings (I&M 1995)

Grammar 1, native strata (Yamato, Sino-Japanese)

*[si] >> *[ti] >> Faithfulness

Grammar 2, Assimilated foreign words:

*[si] >> Faithfulness >> *[ti]

Grammar 3, Unassimilated foreign words:

Faithfulness >> *[si] >> *[ti]
Or: Single ranking, with indexed faithfulness constraints (I&M 1999)

* [si] >> Faith(foreign) >> *[ti] >> Faith(native)
For either approach (cophonologies or single ranking with indexed faithfulness constraints), speakers must assign an item to a lexical category.

This stratum assignment determines whether particular structures are possible in that lexical item.
Experiment I

Subjects: 14 Japanese NSs (in Japan)
          25 English NSs (in U.S.)

Stimuli: nonwords (LHH) produced by bilingual J-E

\textit{fati}CV, \textit{fachi}CV (foreign context)
\textit{hyati}CV, \textit{hyachi}CV (native context)

Task: ABX discrimination
      (e.g., \textit{hyatire-hyachire-hyatire})
Expected results

If discrimination is stratum-specific, then we expect a manner/stratum interaction for Japanese speakers:

- Poor *si/shi* discrimination in both native and foreign stratum.
- Better *ti/chi* discrimination in foreign than in native stratum.
Results (Stratum)

Japanese

Accuracy

Native | Foreign

English

Stop | Fricative

Native | Foreign

Accuracy
Results (Stratum)
Results

• Better discrimination of $ti/chi$ than $si/shi$, in both strata.

• This asymmetry held for both language groups, Japanese and English.

• No stratum effect for Japanese (or English) groups.
Questions

Question 1: Why was a **manner effect** found (better discrimination of $ti/chi$ than $si/shi$) for English listeners?

Question 2: Why was no **stratum effect** found for Japanese listeners? (*Contra* both Moreton & Amano and Gelbart & Kawahara studies)
Manner effect: *ti/chi* inherently less confusuable than *si/shi*

- *ti* vs. *chi*: both place and manner (absence vs. presence of frication).
- *si* vs. *shi*: place only.
- Fricative cues are subtle. Main cues for English *s-sh* (/s/ -/ʃ/)= centroid frequency; main cues for Japanese *s-sh* (/s/ -/ɕ/): onset F2 frequency (Li, Edwards, & Beckman 2007, 2009).
Perceptual salience asymmetry can explain historical development


Shaw 2007, Shaw & Balusu 2010:
• In articulation, $ti/chi$ are generally distinct (at least for younger speakers).
Acceptance of *ti* not explainable by frequency difference

Crawford, pc: English words with initial *[ti, di]* and *[si, zi]* borrowed into Japanese (from Arakawa’s loanword dictionary):

- *[ti]*: 23
- *[di]*: 40
- *[si]*: 124
- *[zi]*: 6

So Japanese speakers were probably exposed to MORE violations of *[ti]* than *[si]* (yet ranked *[si]>>*[ti]*).
Summary: Manner effect

• Both Japanese and English speakers show better discrimination of \( ti/chi \) than \( si/shi \).

• This reflects inherent difference in perceptual salience of contrast.

• This perceptual asymmetry explains the emergent ranking \([si] \gg Faith \gg *[ti]\) in Japanese.
Why no stratum effect?

Previous studies (Moreton & Amano, Gelbart & Kawahara) showed effect of stratum on position of perceptual category boundaries.

Why did our study NOT show an effect of stratum on perception?
Possibility 1: orthographic vs. aural presentation?

Gelbart & Kawahara 2007 presented options
• in katakana for foreign.
• in hiragana for native.

But: Moreton & Amano used only katakana, and “Gelbart (2005) obtained similar bias effects...in languages that do not use different orthographic systems for different strata...”
Possibility 2: type of contrast?

- M&A, G&K: duration ([a] vs. [aa], [g] vs. [gg]).

- Our study: place, manner (ti vs. chi, si vs. shi).
Possibility 3: persistent discrimination?

Perhaps the ability to perceive a contrast cannot be ‘turned off’ (even where such contrasts are not possible).

Cf. Escudero & Boersma (2002): Dutch learners of Spanish tended to perceive 3 vowel categories in Spanish [i-e] space, corresponding to their NL categories (though Spanish distinguishes only 2 categories).
Possibility 4: level of processing?

Our study: discrimination.

The discrimination task may simply reflect lower-level auditory processing, while the identification/categorization tasks tapped into phonological processing.
Experiment 2

Question: Do stratal effects appear in tasks involving lexical access?


Task: Lexical decision (word/nonword) with repetition priming.
### si/shi and ti/chi

possibility of contrast determined by stratum

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<tr>
<td></td>
<td>Word</td>
<td>Transformed Word</td>
</tr>
<tr>
<td>----------------</td>
<td>------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Native</td>
<td>shimin</td>
<td>*simin</td>
</tr>
<tr>
<td></td>
<td>chika</td>
<td>*tika</td>
</tr>
<tr>
<td>Loan</td>
<td>shiisoo</td>
<td>*siisoo</td>
</tr>
<tr>
<td></td>
<td>chiimu</td>
<td>tiimu</td>
</tr>
</tbody>
</table>
Predictions

Japanese speakers should be more likely to

• accept *si* forms than *ti* forms, in both strata (i.e., their perception grammars should map *simin, siisoo* onto *shimin* ‘citizen’, *shiisoo* ‘seesaw’).

• accept *ti* forms as variants of *chi* forms in native than in foreign strata.
Results

• First, participants accurately rejected nonwords and accepted real words ~ 90%.
Second, transformed words (both $shi>si$ and $chi>ti$) were significantly less likely to be accepted than real words, in both strata.

But as expected, transformed $shi>si$ forms were significantly more likely to be accepted than transformed $chi>ti$ forms.
The rejection of transformed words is consistent with the discrimination results showing that listeners could distinguish both contrasts with accuracy ~80% or better.

The greater acceptance of *si* variants is consistent with the finding that listeners find it harder to discriminate *shi/si* than *chi/ti*. 
Effect of stratum?

Predicted result: *ti* forms should be more likely to be accepted as variants of native words (where no contrast is possible) than as variants of loanwords (where contrast is possible). No native/foreign difference expected for *si* forms.

Actual result: both *si* and *ti* forms were more readily accepted as variants of loans than of native words.
Percentage of ‘word’ responses

<table>
<thead>
<tr>
<th></th>
<th>$si$</th>
<th>$ti$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native</td>
<td>33%</td>
<td>22%</td>
</tr>
<tr>
<td>Loan</td>
<td>63%</td>
<td>38%</td>
</tr>
<tr>
<td>Difference</td>
<td>30%</td>
<td>16%</td>
</tr>
</tbody>
</table>
Puzzles

1. Why is *ti*-variant accepted more often for loans than for native words? (Reverse effect was expected if speakers attend to contrast only in foreign forms.)

2. Why is *si*-variant accepted more often for loans than for native words? (No stratum effect was expected for *si.*)
Acceptance of *ti*-variants in loans

Could this be due to the fact that more of the English source words contained *ti* than *chi*?

**NO:**

- No significant difference in response for loans corresponding to English *ti* vs. *chi*.
- Similarly, no difference in response for source words containing *si* vs. *shi*. 
Why were *ti*-variants of loans accepted?

- Speakers can generally discriminate *ti/chi*.
- Speakers have distinct lexical representations for *ti* and *chi* words in foreign stratum.
- Therefore, they know a word containing *ti* is a POSSIBLE foreign-origin word (but not a possible native word). (Note that acceptance rate was still relatively low.)
But why are *si-variants* accepted more often in loans?

- Presumably, failure to discriminate *si/shi* is constant across strata, so why much greater acceptance in loans (63% loan, 33% native)?

- Cannot appeal to difference in possible lexical representations /si/, /shi/ (in either stratum).
Stratum-specific category flexibility

• *shi* exemplars for native words correspond to typical native pronunciation.

• *shi* exemplars for foreign words include a range of pronunciations from speakers with varying degrees of bilingualism.
Therefore, Japanese speakers’ *shi* category might be more accommodating (i.e., accepting of wider variation) for foreign-origin words than for native-origin words.
Perception of s/sh

Li, Munson, Edwards, Yoneyama, & Hall 2011

For “ambiguous or intermediate speech sounds”:

• English listeners are more likely to assimilate them to <s> category.

• Japanese listeners are more likely to assimilate them to <sh> category.
Summary

• Japanese speakers discriminate *ti/chi* better than *si/shi*, regardless of stratal cues.

• This asymmetry holds cross-linguistically, and explains the emergent ranking accounting for (e.g.) *shitibaNku* ‘Citibank’.
Japanese speakers show fairly low rate of acceptance for *ti* (22%) and *si* (33%) variants of native words, consistent with the impossibility of these structures in native vocabulary.
Japanese speakers’ greater acceptance of *si* than *ti* variants reflects their difficulty in discriminating *si/shi*.

Japanese speakers’ greater acceptance of *si* variants in loanwords reflects the greater flexibility of their foreign *shi* category, suggesting stratum-specific effects that are more subtle than simple sensitivity to possibility of contrast within a stratum.
Conclusion

- Within a language with coexisting production grammars, we do see effects on perception, though these reflect a complex interaction between the levels of acoustic, phonological, and lexical processing.
Thanks to

- Yukiko Asano, Sara Catlin, Jessica Fareri, Sophia Kao, Jennifer Park, Eriko Sato-Zhu, and Hisako Takahashi
- NSF Grant BCS-07460227
Selected References


# Priming

<table>
<thead>
<tr>
<th>Prime</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>shi</td>
<td>shi</td>
</tr>
<tr>
<td>shi</td>
<td>si</td>
</tr>
<tr>
<td>chi</td>
<td>chi</td>
</tr>
<tr>
<td>chi</td>
<td>ti</td>
</tr>
</tbody>
</table>