The Perception of Novel Phoneme Contrasts in a Second Language: A Developmental Study of Native Speakers of English Learning Japanese Singleton and Geminate Consonant Contrasts

Rachel L. Hayes
University of Arizona

1. Introduction

This work explores development in the perception of Japanese singleton and geminate consonant contrasts among native speakers of English learning Japanese as a second language. The primary goal of this paper is to show that the second language (L2) acquisition of phoneme contrasts that are not present in the first language (L1) exhibits development that is predictable from the acoustic properties of the contrast. Additionally I attribute differences in the perception of particular singleton/geminate contrasts by both native speakers of Japanese and learners of Japanese as a result of acoustic properties of the contrasts.

The organization of this paper is as follows: Section 2 provides an account of singleton and geminate consonant contrasts in English and Japanese, and introduces a model of the perception grammar of each language that accounts for the presence or absence of the contrasts. Section 3 presents a model of second language acquisition and the influence of the first language grammar on the development of the second language. In section 4 I discuss the acoustic properties of singleton/geminate contrasts. Section 5 gives the details of a second language perception experiment designed to uncover developmental stages in L2 perception of singleton/geminate contrasts. Section 6 introduces an analysis of L2 developmental stages and variation at each stage. And section 7 provides a discussion of the conclusions and directions for future research.

2. Singleton and Geminate Consonant Contrasts in English and Japanese

For the purposes of this discussion, singleton refers to a single consonant segment, and is differentiated from a geminate, or double consonant, by phonological length. In some languages, such as English, consonant length is not contrastive morpheme-internally. However, in other languages such as Japanese, consonant length can be phonemic; that is, Japanese has singleton/geminate phoneme contrasts. Examples of Japanese singleton/geminate phoneme contrasts are provided in (1).

* Thanks to Mike Hammond, Janet Nicol, Mary Zampini, Robert Kennedy, Tania Zamuner, Sonya Bird, Cathy Hicks, Tim Vance, and Ian Maddieson for their advice and suggestions. I would also like to thank Kazutoshi Ohno, Keiichiro Suzuki, and Mizuki Miyashita for their help in developing and recording the stimuli. All errors are my own.

1 English does have singleton and geminate contrasts across morpheme boundaries (e.g., top pick versus topic).
The Perception of Novel Phoneme Contrasts in a Second Language

(1) Japanese Singleton/Geminate Minimal Pairs

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>kisaki</td>
<td>‘empress’</td>
<td>kissaki</td>
</tr>
<tr>
<td>kika</td>
<td>‘your home’</td>
<td>kikka</td>
</tr>
<tr>
<td>oto</td>
<td>‘sound’</td>
<td>otto</td>
</tr>
</tbody>
</table>

The difference between English and Japanese singleton/geminate consonant contrasts are accounted for within a constraint-based model of perception. The present analysis makes use of insights provided by Optimality Theory to characterize the differences between the phoneme inventories of Japanese and English.

2.1 Optimality Theory

Optimality Theory (Prince and Smolensky 1993) is a theory of constraint interaction. Grammatical constraints, which are innate, interact according to their language-specific hierarchical priorities. Given a theoretically infinite set of candidate structures, the constraint hierarchy determines the optimal candidate, which is the output of the grammar and what the speaker produces.

Traditionally, the literature in Optimality Theory has been dedicated to explaining aspects of language production. This paper adopts the Optimality Theoretic mechanism to account for language perception. The following section introduces the perception-based model and its application to explaining phoneme inventories.

2.2 An Optimality-Theoretic Perception Grammar

In the perception-based grammatical model adopted in this paper, ‘input’ refers to what the listener hears (the phonetic stimulus), not the underlying form as in the traditional Optimality-Theoretic sense of input. The optimal candidate, or ‘output,’ is what the listener perceives. The percept is the phoneme underlying the phonetic form of the input, and the role of the grammar in speech perception is to assign each input segment to an underlying phoneme category.

Thus the difference between languages with different phoneme inventories is how each grammar assigns input segments to phoneme categories. Modeling the difference between the singleton/geminate phoneme inventories of languages like English and Japanese can be accomplished with the interaction of the following perception-based constraints.

(2) The IDENT-GEMINATE and *GEMINATE Constraints

<table>
<thead>
<tr>
<th>IDENT-GEMINATE</th>
<th>The input consonant length and the perceived consonant length must be identical.</th>
</tr>
</thead>
<tbody>
<tr>
<td>*GEMINATE</td>
<td>Geminate consonants are not perceived as distinct from their singleton counterparts.</td>
</tr>
</tbody>
</table>

The constraint IDENT-GEMINATE requires that the length of input segments and the perceived phoneme length be the same. This means that a geminate input must be perceived as a geminate consonant. *GEMINATE directly contradicts the IDENT-GEMINATE constraint. *GEMINATE requires that all input segments be perceived as singletons. Given these two constraints, languages which have singleton/geminate consonant contrasts would have the ranking IDENT-GEMINATE >> *GEMINATE, while languages which do not would then have the ranking *GEMINATE >> IDENT-GEMINATE. Examples are provided in (3) and (4).
(3) A language with no singleton/geminate consonant contrast (e.g., English)\(^2\)

<table>
<thead>
<tr>
<th>Input: [tt]</th>
<th>*GEMINATE</th>
<th>IDENT-GEMINATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>/t/</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>/tt/</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

(4) A language with a singleton/geminate consonant contrast (e.g., Japanese)

<table>
<thead>
<tr>
<th>Input: [tt]</th>
<th>IDENT-GEMINATE</th>
<th>*GEMINATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>/t/</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>/tt/</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If *GEMINATE outranks IDENT-GEMINATE, geminate consonants in the input are perceived as singletons, since it is more important to assign the percept to an underlying geminate than it is to be faithful to its surface length. Conversely, if IDENT-GEMINATE outranks *GEMINATE, it is more important that what is perceived be faithful to the input length than that there not be geminates in the phoneme inventory.

The perception grammars of English and Japanese proposed so far are too simple. The distribution of singleton and geminate contrasts cross-linguistically indicates that languages that have singleton/geminate contrasts do not necessarily have this contrast for every consonant in their inventory. For example, Italian, a language with a large singleton/geminate inventory, does not have a surface contrast for singleton and geminate /s/, because singleton /s/ surfaces as [z], while geminate /ss/ surfaces as [ss]. Similarly, Japanese has the /s/ versus /ss/, /t/ versus /tt/, and /k/ versus /kk/ contrasts, but no /p/ versus /pp/ contrast in the core lexicon. For this reason the constraint *GEMINATE is broken down to distinguish particular singleton/geminate contrasts. Examples of these constraints are formalized below in (5).\(^3\)

(5) *GEMINATE split into component constraints

<table>
<thead>
<tr>
<th>*ss</th>
<th>Geminate /ss/ is not perceived as distinct from singleton /s/.</th>
</tr>
</thead>
<tbody>
<tr>
<td>*kk</td>
<td>Geminate /kk/ not perceived as distinct from singleton /k/.</td>
</tr>
<tr>
<td>*tt</td>
<td>Geminate /tt/ is not perceived as distinct from singleton /t/.</td>
</tr>
</tbody>
</table>

Thus a language which contrasts /t/ versus /tt/, /k/ versus /kk/, and /s/ versus /ss/ will have the following ranking: IDENT-GEMINATE >> *ss, *kk, *tt, and a language which does not would have the ranking *ss, *kk, *tt >> IDENT-GEMINATE. This new set of constraints further allows us to model, for example, a language with a /t/ versus /tt/ contrast, but no /k/ versus /kk/ or /s/ versus /ss/ contrasts: *kk, *ss >> IDENT-GEMINATE >> *tt. Tableaux are provided in (6).

---

\(^2\) The ‘!’ indicates the optimal candidate, which is the output of the grammar, and is what the listener perceives. ‘!’ indicates that a candidate has incurred a fatal violation and cannot be optimal.

\(^3\) Because /t/ versus /tt/, /s/ versus /ss/, and /k/ versus /kk/ are the contrasts of interest in this paper, only the constraints having to do with these contrasts are discussed. Although they are not discussed here, similar constraints (e.g., *pp, *nn) are hypothesized to exist.
In (6), a [tt] input is perceived as a geminate /tt/, but a [ss] input is perceived as a singleton /s/. In this way the relative ranking of the individual *GEMINATE constraints relative to IDENT-GEMINATE determines the geminate inventory of the language. Japanese has the ranking IDENT-GEMINATE >> *ss, *kk, *tt, which is illustrated in (7). Because IDENT-GEMINATE outranks the *GEMINATE constraints *ss, *kk, and *tt, there are /t/ versus /tt/, /s/ versus /ss/, and /k/ versus /kk/ contrasts in Japanese.

And English has the ranking *ss, *kk, *tt >> IDENT-GEMINATE, illustrated in (8). Because the *GEMINATE constraints *tt, *ss, and *kk are ranked above Ident-Geminate, there are no /s/ versus /ss/, /k/ versus /kk/, or /t/ versus /tt/ contrasts in English.

The following section introduces a model of second language acquisition where the native language grammar is the initial state in second language acquisition. Under this model, native speakers of English learning Japanese as a second language will begin the process of acquiring Japanese with the English hierarchy presented in (8), and subsequent development of Japanese will reflect a reranking of the relevant constraints to more closely match the Japanese hierarchy presented in (7).

3. The Full Transfer/Full Access Model of Second Language Acquisition

In this paper it is assumed that the initial state in the acquisition of a second language is the first language grammar (Schwartz and Sprouse 1996). Previous studies of second language acquisition have shown that learners exhibit strong transfer of the first language grammar to second language speech perception and production in the early stages of second language acquisition (Hayes Hancin-Bhatt and Bhatt 1997a/1997b, Hayes 2000). It is therefore
predicted that native speakers of English learning Japanese as a second language will initially indicate strong influence from English and gradually develop more target-like perception.

Under these assumptions, developmental stages in the acquisition of Japanese as a second language should reflect re-rankings of the L1 English hierarchy and subsequent interlanguage\(^4\) hierarchies to more accurately reflect the target Japanese hierarchy.

4. The Acoustics of Singleton/Geminate Consonant Contrasts

This section explores the phonological and acoustic properties of singleton/geminate stop contrasts. Consonant duration is an important cue to the perception of singleton/geminate contrasts (Obrecht 1965, Repp 1978, Lisker 1957). In stop consonants, the singleton/geminate contrast is manipulated primarily in the duration of the stop closure, while in fricatives, the contrast is manipulated primarily in the duration of frication.

In the present acoustic analysis, a native speaker of Japanese\(^5\) produced Japanese nonwords in isolation for acoustic analysis.\(^6\) The items were designed to elicit singleton/geminate pairs for each of three consonants (/s/ versus /ss/, /t/ versus /tt/, and /k/ versus /kk/), and the speaker produced each item ten times. These items are a subset of those used in the perception experiment presented in section 5. Each token was analyzed for stop closure or frication duration, duration was averaged across the ten tokens of each item, and singleton/geminate consonant length duration differences were calculated.

(9) Stop Closure and Frication Duration of Japanese Singleton/Geminate Consonant Pairs

<table>
<thead>
<tr>
<th>Singleton/Geminate</th>
<th>Singleton Stop Closure Duration</th>
<th>Standard Deviation</th>
<th>Geminate Stop Closure Duration</th>
<th>Standard Deviation</th>
<th>Difference (Geminate Duration minus Singleton Duration)</th>
</tr>
</thead>
<tbody>
<tr>
<td>t/tt</td>
<td>95.71</td>
<td>9.46</td>
<td>276.06</td>
<td>21.66</td>
<td>180.34</td>
</tr>
<tr>
<td>k/kk</td>
<td>81.73</td>
<td>9.32</td>
<td>223.55</td>
<td>21.69</td>
<td>141.82</td>
</tr>
<tr>
<td>s/ss</td>
<td>136.08</td>
<td>12.40</td>
<td>270.08</td>
<td>11.15</td>
<td>134.01</td>
</tr>
</tbody>
</table>

---

\(^4\) Interlanguage refers to a second language grammar, at any stage of development.

\(^5\) This speaker was one of the two native speakers of Japanese who produced the experiment stimuli.

\(^6\) All acoustic analysis was performed with Praat.
4.1 Predictions of Relative Perceptibility of the Singleton/Geminate Contrasts in Japanese

Here I explore the relative durational differences among the particular singleton/geminate contrasts and make predictions about the relative perceptibility of the contrasts based on these durational differences. Relative perceptibility refers to the relative ability that native speakers of English should have in detecting the Japanese singleton/geminate contrasts due to the durational properties of the contrasts.

The analysis of the production of Japanese /s/ versus /ss/ and /t/ versus /tt/ indicates that while geminate /tt/ and /ss/ have the same average duration (270-276 msec), singleton /t/ is much shorter (95.71 msec) than singleton /s/ (136.08 msec). The difference in duration, then, between a singleton /t/ and a geminate /tt/ (180.34 msec) is larger than the difference between a singleton /s/ and a geminate /ss/ (134.01 msec). Consistent with the present finding, in a study of Italian singleton/geminate consonant production, Giovanardi and Di Benedetto (1998) found that the length differential between singleton/geminate stops was larger than that of fricatives. If learners do make use of durational information in the distinction of singleton and geminate consonants in Japanese, it is predicted that this difference will make the /t/ versus /tt/ distinction easier for learners of Japanese to perceive than the /s/ versus /ss/ distinction.

The analysis of the production of Japanese /k/ versus /kk/ and /t/ versus /tt/ indicates that while singleton /t/ and /k/ have the same average duration (95.71 msec for /t/ and 81.73 msec for /k/), geminate /kk/ is shorter (223.55) than geminate /tt/ (276.06 msec). The difference in duration, then, between a singleton /t/ and a geminate /tt/ (180.34 msec) is larger than the difference between a singleton /k/ and a geminate /kk/ (141.82 msec). It is predicted that this will make the /t/ versus /tt/ distinction easier for learners of Japanese to perceive than the /k/ versus /kk/ distinction.

Finally, as the duration differences for /s/ versus /ss/ and /k/ versus /kk/ are very close (134.01 msec and 141.82 msec, respectively), no difference is predicted in the relative perceptibility of these two contrasts.

The developmental second language perception experiment presented below was designed to test the predictions of the relative perceptibility of particular singleton and geminate consonant contrasts in light of the acoustic data presented above.

5.1.2 Perception Experiment: Singleton/Geminate Consonant Contrasts

An experiment tested native English speakers’ sensitivity to Japanese singleton/geminate consonant contrasts. Because English does not have singleton/geminate contrasts, native English speakers learning Japanese must learn to perceive the distinction in order to achieve target-like perception of Japanese.

5.1 Hypotheses

The hypotheses are based on the findings reported in sections 3 and 4.

5.1.1 The Experience Hypothesis

Based on the Full Transfer/Full Access model of second language acquisition presented in section 4, native English speakers with no Japanese language training will exhibit poor sensitivity to singleton/geminate contrasts in Japanese. Learners with more Japanese language experience will exhibit progressively stronger sensitivity.

---

7 Giovanardi and Di Benedetto (1998) calculated length differentials (geminate length divided by singleton length), and found that geminate stops have a length that is 201% the length of their singleton counterparts, while geminate fricatives are 173% the length of their singleton counterparts.
5.1.2 The Acoustics Hypothesis

Based on the predictions discussed in section 4.1, participants will exhibit better sensitivity to the /t/ versus /tt/ contrast than to the /s/ versus /ss/ or /k/ versus /kk/ contrasts. And there will be no difference between their perception of the /s/ versus /ss/ and /k/ versus /kk/ contrasts.

5.2 Method

Subjects listened to a recording by two male native speakers of Japanese of 120 pairs of Japanese nonwords. They were asked to determine whether the two utterances were of the same Japanese word or of two different Japanese words. Subjects recorded their answers by marking “same” or “different” for each pair on a sheet of paper. Although all of the stimuli were nonwords, subjects were told that they would be hearing Japanese words, of which some might be unfamiliar to them.8

5.3 Items

All items were well-formed but non-occurring bisyllabic Japanese words.9 Of the 120 pairs presented, 60 were of the same word (filler pairs) and 60 were different words (target pairs). The basic structure was (C)V.CV for singleton items and (C)VC.CV for geminate items.

(10) Target Pair Conditions 10

<table>
<thead>
<tr>
<th>Condition name</th>
<th>Comparison</th>
<th>Structure of items in this condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>/t/ vs. /tt/</td>
<td>(C)V.tV → (C)Vt.tV</td>
</tr>
<tr>
<td>S</td>
<td>/s/ vs. /ss/</td>
<td>(C)V.sV → (C)Vs.sV</td>
</tr>
<tr>
<td>K</td>
<td>/k/ vs. /kk/</td>
<td>(C)V.kV → (C)Vk.kV</td>
</tr>
</tbody>
</table>

A “same” pair consisted of two presentations of the same word (e.g., noka/noka or nokka/nokka), and a “different” pair consisted of two different words (e.g., noka/nokka). The “different” pairs were the pairs of interest; an incorrect “same” response to a pair in the “different” condition was scored as an error. Error rates are presented in section 5.5.

In (11) I restate the specific predictions of the Acoustics Hypothesis—the relative perceptibility of the singleton-contrasts outlined in 4.1.

(11) Predictions of the Acoustics Hypothesis

T and S → T is easier to perceive
T and K → T is easier to perceive
S and K → no difference

5.4 Participants

All participants were undergraduate students at the University of Arizona. There was a control group of native speakers of English without Japanese training (Level 0, n=20). The Level 1 group comprised students in first-semester Japanese language courses at the University (n=26); Level 2 comprised students in second-semester Japanese language courses (n=11); and Level 3 comprised students in the third and fourth semesters of Japanese language study (n=17). In (12) I restate the predictions of the Experience Hypothesis.

8 Subjects were informed immediately following the task that all of the stimuli were in fact nonwords.
9 Three native Japanese speakers verified the nonword status of the stimuli.
10 ‘C’ and ‘V’ refer to consonant and vowel, respectively; ‘.’ indicates a syllable boundary.
(12) Predictions of the Experience Hypothesis

- Level 0 → Poor sensitivity to Japanese singleton/geminate contrasts
- Level 1 → Stronger sensitivity to the contrasts than Level 0
- Level 2 → Stronger sensitivity to the contrasts than Level 1
- Level 3 → Stronger sensitivity to the contrasts than Level 2

5.5 Results

The data was scored by totaling the number of incorrect ‘same’ responses. I begin by discussing the Experience Hypothesis. The performance of the subjects indicates that over the course of Japanese language study, native English speakers learning Japanese develop increased sensitivity to singleton/geminate contrasts overall.

(13) Error Rates By Level (collapsed across item condition)

The data presented in (13) indicate improvement in the subjects’ performance over length of exposure to Japanese language study. Level 3 performance is better than Level 0 performance in a subjects analysis (F(1,36)=6.068; p<0.05), confirming the Experience Hypothesis. Differences between adjacent levels are not significant, but the general pattern of improvement over time is apparent in the downward slope of the percent error.

The following chart provides the results broken down by item condition in order to evaluate the Acoustics Hypothesis.
When the data are broken down by item condition, the differences in results for particular singleton/geminate contrasts are evident. At all levels, the error rates for the /t/ versus /tt/ condition were lower than the /k/ versus /kk/ condition. The perception of the /k/ versus /kk/ and /t/ versus /tt/ contrasts are significantly different at Level 1 (F(1,25)=17.588; p<0.0001); Level 2 (F(1,10)=1.796, p=0.0515; and Level 3 (F(1,17)=2.005, p<0.05). Levels 1 and 3 are different in the /s/ versus /ss/ condition (F(1,42)=4.253; p<0.05). The perception of the /s/ versus /ss/ and /t/ versus /tt/ contrasts is different at Level 1 (F(1,25)=23.740; p<0.0001); Level 2 (F(1,10)=9.193; p<0.05); and Level 3 (F(1,17)=11.533; p<0.005). There is no difference between the S and K conditions at any level. The differences between the T condition and both the S and K conditions and the lack of differences between the S and K conditions at levels 1, 2, and 3 confirm the Acoustics Hypothesis.

### 6. An Interlanguage Perception Grammar

The results show developmental stages in the acquisition of Japanese singleton/geminate contrasts, and indicate that there is variation in the perception grammars of the learners as they progress through the acquisition of Japanese. Assuming that native speakers of English begin the process of learning a second language with a full instantiation of the English grammar (i.e., the Full Transfer/Full Access model of Schwartz & Sprouse 1996), the starting point should be the following hierarchy: *kk, *ss, *tt >> IDENT-GEMINATE (the English hierarchy). However, the control group did show considerable sensitivity to singleton/geminate contrasts. Given that subjects in the control group have no previous knowledge of Japanese, it is not clear exactly what information they use when making their judgments. Since they presumably have no knowledge of the phoneme inventory of Japanese, their judgments cannot realistically be interpreted as indicating what they believe to be contrastive in Japanese. This issue will be explored in future research.
6.1 Interlanguage variation as variable, weighted constraint rankings

Interlanguage variation is viewed in this paper as resulting from variable constraint rankings. This analysis encodes probabilities as weighted ranking tendencies. For example, given two constraints ALPHA and BETA, a first language with the ranking ALPHA >> BETA, and a target language with the ranking BETA >> ALPHA, acquisition of the target ranking will proceed as ALPHA increasingly tends to be ranked below BETA. The learner makes use of a learning algorithm such as that introduced by Tesar & Smolensky (1996), where data which indicate a target language constraint ranking different from the current state of the learner grammar stimulates re-ranking of the relevant constraints. Thus, given data which indicate that the target grammar ranks BETA >> ALPHA, the learner-grammar will gradually re-rank ALPHA below BETA. This process is one of evolving tendencies; that is, ALPHA does not suddenly and completely rank below BETA. Instead, the learner-grammar increasingly tends to rank ALPHA below BETA. Thus, at any step in the interlanguage grammar, the tendency for ALPHA to be ranked below BETA is indicated by the percentage in the box below the constraint.12

(17) Example ranking tendencies for ALPHA and BETA

<table>
<thead>
<tr>
<th>Input: [delta]</th>
<th>ALPHA</th>
<th>BETA</th>
</tr>
</thead>
<tbody>
<tr>
<td>(80%) /Candidate 1/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(20%) /Candidate 2/</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

20%

In (17), ALPHA is ranked below BETA 20% of the time. As a result, the grammar chooses Candidate 1 80% of the time, and Candidate 2 20% of the time. This model can be applied to the developmental data from the present study. The experimental results can be interpreted as indicating the evolution of grammatical tendencies over time, and each level of Japanese study can be represented as a constraint hierarchy with particular ranking tendencies. The tableau in (18) is of the initial state in the acquisition of Japanese (taken from Level 0 subjects).

11 The exact nature of the learning algorithm is not of immediate concern. It suffices to mention that there are theoretical mechanisms available to account for acquisition of a grammar as changing OT constraint rankings.

12 As a matter of convention, I assume that the initial (native language) ranking is the default one, and that the target (second language) ranking is the one indicated by an arrow and a probability.
The tableau in (18) can be read as indicating the following: The ranking is (*kk, *ss) >> IDENT-GEMINATE >> *tt 63.33% percent of the time. The ranking is (*kk, *tt) >> IDENT-GEMINATE >> *ss 56.73% of the time. And the ranking is (*ss, *tt) >> IDENT-GEMINATE >> *kk 58.75% of the time.

The next tableau shows the first interlanguage stage, where each of the re-ranking tendencies has gotten stronger than in Level 0.

---

13 The *kk and *ss constraints are in parentheses because I am not making any claim about the relative rankings of them to either IDENT-GEMINATE or *tt; just the relative rankings of IDENT-GEMINATE and *tt.
At level 2, all of the *GEMINATE constraints have a stronger tendency to be ranked below IDENT-GEMINATE, resulting in an advanced interlanguage grammar.

(20) Proposed Level 2 Japanese Interlanguage Grammar

<table>
<thead>
<tr>
<th>Input: [kk]</th>
<th>*kk</th>
<th>*ss</th>
<th>*tt</th>
<th>IDENT-GEMINATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>(34.09%) /k/</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>(65.91%) /kk/</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Input: [ss]</td>
<td></td>
<td>*ss</td>
<td></td>
<td>IDENT-GEMINATE</td>
</tr>
<tr>
<td>(42.4%) /s/</td>
<td>*kk</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>(57.6%) /ss/</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input: [tt]</td>
<td></td>
<td></td>
<td>*tt</td>
<td>IDENT-GEMINATE</td>
</tr>
<tr>
<td>(24.24%) /t/</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>(75.76%) /tt/</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

Input: [kk] (65.91%) /kk/ (34.09%) /k/ (24.24%) /t/ (75.76%) /tt/ (57.6%) /ss/ (42.4%) /s/ 65.91% 57.6% 75.76%

Finally, the most advanced Japanese learners in the study contributed the data for the grammar represented in the tableau in (19). In the level 3 grammar, the tendencies for the *GEMINATE constraints to be ranked below IDENT-GEMINATE are stronger than in level 2.

(21) Proposed Level 3 Japanese Interlanguage Grammar

<table>
<thead>
<tr>
<th>Input: [kk]</th>
<th>*kk</th>
<th>*ss</th>
<th>*tt</th>
<th>IDENT-GEMINATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>(28.66%) /k/</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>(71.34%) /kk/</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Input: [ss]</td>
<td></td>
<td>*ss</td>
<td></td>
<td>IDENT-GEMINATE</td>
</tr>
<tr>
<td>(33.79%) /s/</td>
<td>*kk</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>(66.21%) /ss/</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input: [tt]</td>
<td></td>
<td></td>
<td>*tt</td>
<td>IDENT-GEMINATE</td>
</tr>
<tr>
<td>(21.04%) /t/</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>(78.96%) /tt/</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

Input: [kk] (71.34%) /kk/ (28.66%) /k/ (78.96%) /tt/ (66.21%) /ss/ (33.79%) /s/ 65.91% 66.21% 78.96%

The tableaux in (18) – (21) provide a model of the interlanguage grammars of learners of Japanese with respect to the perception of singleton/geminate consonant contrasts. The analysis shows that variability in second language
performance is the result of unstable interlanguage grammars; that is, grammars which have variable constraint rankings. There are tendencies associated with each ranking, where second language learners start the acquisition process with weak tendencies toward target-like perception, but the ranking tendencies are strengthened over exposure to the target language, ultimately resulting in perception which more closely matches the target language.

7. Conclusions

This study has shown that the differences between the perception grammars of English and Japanese can be modeled by different rankings of a set of perception-based constraints. This contributes to the existing literature in the Optimality-Theoretic paradigm by providing additional evidence for the utility of constraint interaction in characterizing cross-linguistic variation. This analysis further allows for the distinction of the perception of particular singleton/geminate consonants, by breaking down a general constraint against the perception of inputs as geminates (*GEMINATE) into constraints which target particular geminates (*TT, *ss, *kk). I have also provided acoustic evidence in support of the different relative perceptibility of particular singleton/geminate contrasts by showing that singleton/geminate length differentials make predictions about relative perceptibility.

The results of the developmental second language perception experiment reported here find a natural interpretation within the predictions of the constraint-based perception grammars, and indicate that second language learners begin the process of L2 learning with native-language-based perception of L2 phoneme contrasts, but can develop more target-like perception over length of L2 study and exposure. Additionally, the relative perception of the particular singleton/geminate contrasts confirms the predictions of the acoustic analysis; singleton/geminate contrasts whose length differentials are larger (e.g., /t/ versus /tt/) are easier for learners to perceive than singleton/geminate contrasts with smaller length differentials (e.g., /s/ versus /ss/ or /k/ versus /kk/).

Finally, I propose a model of the variability seen in the L2 learners’ perception within the Optimality-Theoretic notion of grammar as constraint ranking. I propose that interlanguage variability is the result of variant ranking tendencies and that second language acquisition is the result of strengthening tendencies toward more target-like constraint rankings.

7.1 Future Directions

Future research will investigate the nature of the acoustic cues used by native speakers of Japanese, monolingual English speakers, and native English-speaking learners of Japanese to perceive the contrasts between Japanese singleton and geminate consonants. One study will systematically manipulate the acoustic cue of consonant length (stop closure duration for the stops and frication duration for the fricatives) and present the variants to all three subject groups to determine the location of the singleton/geminate category boundaries on the consonant duration continuum for each singleton/geminate pair. It is predicted that monolingual English speakers will require a longer consonant duration to perceive a geminate than native speakers of Japanese, and native English-speaking learners of Japanese will exhibit perceptual boundaries between those of the native Japanese speakers and the monolingual English speakers.

References


The Perception of Novel Phoneme Contrasts in a Second Language


Department of Linguistics
Douglass 200-E
University of Arizona
Tucson AZ 85721
USA
rhayes@u.arizona.edu
http://www.u.arizona.edu/~rhayes/