Predicting Perceptual Success with Segments: A Test of Japanese Speakers of Russian

Jenifer Larson-Hall
Kyushu University

1. Introduction

As in many other areas of language acquisition, non-native speakers usually do not achieve complete nativelike proficiency with the segments of a second language (L2), but they can often perceive some segments which are not found in their first language (L1) inventory. A contrastive analysis approach (such as Lado, 1957) which predicts that only the L2 surface structures which differ from the L1 structures will be difficult for the learner has been found to be too simplistic to explain the data (Ellis, 1994; Gass & Selinker, 2001; Larsen-Freeman & Long, 1991). Research from several different quarters is being undertaken to address the question of how L2 segmental perception works, and several important hypotheses have been put forward lately which try to answer these theoretical and practical concerns. In this paper I test the predictions of two models which have recently been reported to be successful in determining why learners have trouble with some segments of an L2 but not with others.

2. A Featural Model of L2 Perception

Brown (1997) proposes a model which I will call the Featural Model of L2 Perception (FM), which predicts that L2 perceptual abilities are constrained by phonological features. The FM predicts that it is not the L1 *segmental* categories which constrain learners, but the L1 *features*, which exist independently in the grammar. Thus acquisition of phonology does not involve segments per se, but rather the acquisition of the contrastive features of the language, which can be rearranged to form new representations. Brown predicts that if the L1 grammar lacks the feature needed to differentiate an L2 phonological contrast, the learner will be unable to perceive the contrast. However, if the feature needed is present in the L1 grammar, regardless of whether the speaker has ever had any acoustic, phonetic or phonemic experience with the specific L2 segment, the learner will be able to accurately identify the contrast. Brown has tested this hypothesis with Chinese, Japanese, and Korean learners of English on the target contrasts /l-r/, /b-v/, /f-v/, /p-f/ and /s-θ/, and found that it successfully predicted the results for each group.

The FM makes a clear prediction for perception of segments:

> **If an L2 contrast, which differs by at least one feature, uses any feature which is found in the L1 inventory, learners will be able to perceptually distinguish the contrast. Conversely, if an L2 contrast differs by at most only one feature, which is *not* found in the L1 inventory, learners will have difficulty in perception.**

3. Flege's Speech Learning Model

Another model of L2 segmental acquisition, which has received considerable praise and confirmation in recent reviews of second language phonological acquisition (Leather & James, 1996; Major, 2001; Wode, 1996), is Flege's Speech Learning Model (SLM). In Flege's conception, the L1 system becomes attuned to just those contrasts of the language which are meaningful in the L1, so the system becomes resistant to the addition of new categories. Flege believes new categories can be learned, however, if they are 'new', that is, different enough from existing L1 categories that the learner

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perceives them as different. Sounds which are exactly the same in all particulars will presumably not present a problem, but sounds which are 'similar' to existing L1 categories will be equated with the L1 categories and will not precipitate the formation of new categories, thus presenting the largest difficulty for learners. Acquisition consists of the learner perceptually relating "positional allophones in the L2 to the closest positionally defined allophone (or "sound") in the L1" (Flege, 1995: 238). Acquisition then consists of the establishment of phonetic categories, not features. There have been numerous studies where the SLM has been used to explain the results which were found (i.e., Flege, 1992a, 1996 for English by Dutch speakers; Flege, Bohn, & Jang, 1997 for English by German, Spanish, Mandarin and Korean speakers; Matsui, 2000 for English, Chinese and Korean learners of Japanese).

In order to predict what will be perceived as a 'new' sound and what will be perceived as a 'similar' sound, Flege has given a heuristic involving the International Phonetic Alphabet (IPA):

> **An L2 sound may be defined as similar if it is represented by the same IPA symbol as a sound in the L1, provided it can be shown to differ auditorily from the corresponding L1 sound. New sounds . . . might be defined as L2 sounds that are represented by an IPA symbol that is *not* used to represent a sound in the L1 (and, of course, which differs auditorily from the nearest L1 sound).** (Flege, 1992b, p. 573)

Although Flege admits that problems with this approach exist, he has not proposed any other easily testable procedures for distinguishing between 'new' and 'similar' sounds, so the IPA system will be used in this paper.

4. Putting the Hypotheses to the Test

In order to test the predictions of these theories, the acquisition of Russian by Japanese learners was examined. One reason the Japanese-Russian pairing is interesting theoretically is that this pairing recasts the traditionally difficult question of the Japanese acquisition of American English /ɹ-l/, since Russian, like English, distinguishes between a lateral and a rhotic. However, the Russian trilled /r/ is phonetically more similar to Japanese /ɾ/ (a tap) than the English approximant /ɹ/. Thus we may investigate whether the English /ɹ-l/ contrast is difficult simply because the English approximant is a difficult and marked sound or whether the problem lies in the lack of a contrast in Japanese between a rhotic and lateral liquid.

I chose to examine eight consonantal segments of Russian: /ʃ, ʒ, l, r, ts, f, p^j, m^j/. These segments ranged from easy to difficult for Japanese learners based on the predictions of both the SLM and FM. For more details on the phonetic and phonemic status of these segments in Russian and Japanese, and the entire segmental inventories postulated for Russian and Japanese, see Larson-Hall (2001).

4.1 The Featural Model of L2 Perception

The first step to determining what predictions the FM makes for these 8 segments of Russian, given that the L1 of the learners is Japanese, is to decide what features are needed in both Russian and Japanese. I used the Feature Geometry (FG) model proposed by Clements & Hume (1995) and Contrastive Underspecification as explained by Steriade (1987). By using underspecification only the features which are contrastive in the given language are postulated to be necessary underlyingly. Both of these choices differed from those used by Brown (1997), as she used a FG that was a composite from several sources and Minimally Contrastive Underspecification.

Leaving aside the details (which the reader will find in Larson-Hall, 2001), the features shown below must be specified for Russian. Palatalization in Russian will be represented, following Clements and Hume's (1995) proposal, by attaching a V-place node with a [coronal] place of articulation underneath the C-place node. This means that palatalized phonemes will not require any additional features to be added to this list.

Russian Features Needed		
[voice]	[continuant]	[labial]
[coronal]	[dorsal]	[nasal]
[anterior]	[distributed]	[lateral]

The determination of the features needed for Japanese is not as straightforward as for Russian, because determining exactly what the phonemes of Japanese are has been more disputed (see Vance, 1987, Tsujimura, 1996 and Ito and Mester, 1995). Because I tested the perception of Japanese college students, who are arguably the most innovative Japanese in terms of language, I included as separate phonemes several segments which might be considered allophonic from a more conservative viewpoint, including /ɸ/, /ts/ and /ʃ/. My inclusion of /ʃ/ as a separate category means that the feature [coronal] is needed underlyingly in Japanese, contrary to Brown (1997).

Again, leaving aside the many necessary details, for Japanese the features that would be needed are found in the figure below.

Japanese Features Needed		
[voice]	[continuant]	[labial]
[coronal]	[dorsal]	[nasal]
[anterior]		

The differences between the featural inventories of Russian and Japanese lie in the necessity of the features [lateral] and [distributed] for Russian, which are not needed in Japanese. The feature [lateral] is needed to distinguish between [r] and [l] in Russian. The feature [distributed] is needed to distinguish between /s/, /ʃ/ and /ɕ/ in Russian, which are all coronal fricatives. I propose that /s/ is [+anterior, -distributed], /ʃ/ is [-anterior, -distributed] and /ɕ/ is [-anterior, +distributed].

The Featural Model of L2 Perception applies to contrasts, and Archibald (1998) and Brown (1997) have argued that the practical way to test whether a learner has acquired a segment is by testing contrasts. Thus, the eight segments of Russian that I am examining were tested through 16 contrasts, such as /ʃ/ vs. /s/. Sounds which differ by more than one feature, but which sound similar acoustically or are produced in articulatorily similar regions or manners were compared without regard to the number of features which differentiated them.

The table below lists the segment being tested, the contrasts used to test them, the features which differentiate between the contrast, and the prediction of the FM for the Japanese learners to perceive the contrast. The features which the FM predicts that Japanese learners do not have are underlined.

There are two contrasts which are predicted to be difficult for Japanese learners of Russian to perceive: /l/ vs /r/, /ʃ/ vs /ɕ/.

Seg	Contrasts	Russian Feature Req.	Jap. hear ?	Seg	Contrasts	Russian Feature Req.	Jap hear ?
/l/	/l/ vs. /r/	lateral	no	/r/[1]	/r/ vs. /l/	lateral	no
	/l/ vs. /lʲ/	V-place	yes		/r/ vs. /rʲ/	V-place	yes
/pʲ/	/pʲ/ vs. /p/	V-place	yes	/f/	/f/ vs. /v/	voice	yes
					/f/ vs. /x/	Place (labial/ dorsal)	yes
	/pʲ/ vs. /bʲ/	voice	yes		/f/ vs. /fʲ/	V-place	yes
/ts/	/ts/ vs. /t/	contin-uant	yes	/mʲ/	/mʲ/ vs. /m/	V-place	yes
	/ts/ vs. /s/	contin-uant	yes				
	/ts/ vs. /tʃ/	anterior	yes				
/ʒ/	/ʒ/ vs. /ʃ/	voice	yes	/ʃ/	/ʃ/ vs. /s/	anterior	yes
	/ʒ/ vs. /z/	anterior	yes		/ʃ/ vs. /ɕ/	distri-buted	no

4.2 Flege's Speech Learning Model

Flege's SLM assumes that allophonic properties of segments determine whether they are correctly perceived or not. Therefore, the first step to determining what predictions the SLM will make for the eight segments of Russian is to compare the allophonic properties of each of the eight sounds in both languages.

The following discussion with detailed information on the segments comes from Jones and Ward (1969) for Russian and Akamatsu (1997) for Japanese. Russian has two liquid phonemes, /l/ and /r/, while Japanese has a single liquid phoneme /ɾ/. The Russian fricative sound /ʒ/ does not exist in Japanese but Japanese does contain an affricate /dʒ/, which is sometimes realized as a fricative [ʑ]. Palatalized sounds, such as the Russian phonemes /pʲ/ and /mʲ/ are found only as allophones of /p/ and /m/ respectively in Japanese. The Russian voiceless labiodental fricative /f/ does not exist in Japanese, but there is a voiceless bilabial fricative /ɸ/. An alveolar affricate /ts/ exists in both Japanese and Russian, but with some minor differences in placement details. Lastly, both Russian and Japanese have a voiceless alveolar fricative /ʃ/ phoneme, but differences in placement details are substantial.

Thus, using the IPA heuristic that was described above, there are 4 segments in Russian for Japanese learners which are 'new': [l], [r], [ʒ], [f] (that is, they use different IPA symbols); 2 segments which are 'similar': [ʃ], [ts] (they use the same IPA symbols but differ auditorily in some particulars); and 2 which are 'same': [pʲ], [mʲ] (they are exactly the same in all phonetic particulars). The table below summarizes the predictions for the SLM.

'same'	Not difficult at all	[pʲ], [mʲ]
'similar'	Difficult to learn	[ʃ], [ts]
'new'	Will eventually learn	[l], [r], [ʒ], [f]

[1] Note that the contrast /r/ vs. /l/ is listed twice--once for /r/ and once for /l/.

5. The Experiment

5.1 Participants

I tested 33 participants who had studied Russian for at least one year at the university level and who were native speakers of Japanese. All Japanese students had spent at least one year of their Russian study with a teacher who was a native speaker of Russian. The Japanese participants were separated into three groups based on oral skill level: Beginner, Intermediate, and Advanced. The grouping into skill level was done by means of a short oral interview, similar to the ACTFL oral proficiency test, but shorter. Another group of native speakers of Russian (NR) was also given the perception test used in this experiment. None of the participants reported hearing problems. All participants were paid for their participation. The table below summarizes the characteristics of the 4 groups, including a rating on how often the learners of Russian used their L2 on a scale from 1-7 (1=no use, 7=always) for three different dimensions: home, school, and social situations, for a range of 3-21 points. The table also includes the number of years the participants had studied Russian at the university level at the time of testing.

	Groups							
	1=Beg M=5, F=6		2=Int M=4, F=8		3=Adv M=2, F=8		4=NR M=1, F=7	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Age	20	19-21	20	19-23	22	20-30	40	25-60
Years of schooling	1.5	1-2	1.8	1-3	3.1	2-4	NA	NA
Use of Russian	5.8	3-12	7	3-12	8	6-9	NA	NA

5.2 Tasks and Materials

The goal of this experiment was to find out whether the Japanese learners of Russian had acquired the eight segments of Russian in question. Archibald (1998) and Brown (1997) have argued that perceptual abilities are better measures of underlying competence than production because they are less susceptible to conscious control (see also Gass, 1984). Brown states that if a speaker can perceive the difference between two L2 segments, this means the correct feature is being used for categorical perception, and the learner has the tools necessary to acquire the phoneme (Brown, 1997: 123). Flege (1995) has stated that he considers the establishment of a 'phonetic category' to include the ability to identify different phones as belonging to the same phoneme as well as the ability to distinguish between different categories. Therefore, a perceptual test using a discrimination task was used here to try to assess whether the learners had actually acquired the segments. It was assumed that a discrimination task testing contrasts would satisfy the requirements of ascertaining acquisition given by both Flege and Brown.

A task called the 4IAX (dual pair discrimination) was used to see whether learners could discriminate between different phonemic categories as well as identify physically different realizations of the same sound as belonging to the same phoneme. In this task, listeners hear four physically different tokens that are grouped into two pairs. One pair of words are a minimal pair while the other pair of words are phonemically the same, but not identical (for example, 'lock, rock; rock, rock'). The listener must identify which pair is different, that is, the minimal pair. Pairs differed only in their initial sound, and pairs of nonce words were used. Stress, which is phonemic in Russian, was always initial. The test consisted of 115 items (comprising 5 items each of 23 contrasts tested[2]) appeared on the perception test. A 1500 millisecond inter-stimulus interval (ISI) was inserted between and inside the two pairs of words, and a 1000 ms pause was inserted before each item (so an item consisted of: 1000

[2] Initially 7 more contrasts than are reported on here were tested. These were removed because they contrasted by more than one feature, which I had later decided was an incorrect use of the FM's predictions.

ms + word + 1500 ms + word; 1500 ms + word + 1500 ms + word). Research by Werker and Logan (1985) has provided evidence that a longer ISI will help cause perception to operate at the phonemic rather than phonetic or acoustic level. The 115 task items were arranged in a random order and downloaded onto a tape. The test took 25 minutes.

5.3 Results

The criteria for nativelike performance by a group on the perception test was a score of at least 84%, which is a rating that falls within two standard deviations of the lowest native Russian mean (.98, SD .07) on any one group of contrasts, and is a standard being used frequently in recent papers (Bongaerts, 1999; Flege, Yeni-Komshian & Liu, 1999). In three cases the scores of one or more of the learner groups were under 84%: [ʃ] vs. [ɕ] (Beg-. 71; Int-. 90; Adv-. 83); [l] vs. [r] (Beg-. 71, Int-. 78, Adv-. 82); [rʲ] vs. [r] (Beg-. 82; Int-. 90; Adv-. 88). A repeated measures ANOVA comparing native speakers and non-native speakers on the 23 contrasts showed that the NR were significantly different from the Japanese learners as a whole, $F(22, 858) = 4.53$, $p < .001$. Another 4 Proficiency level x (16) Contrast ANOVA found a statistically significant effect for Contrast, $F(15, 555) = 14.10$, $p < .001$, Proficiency level, $F(3, 37)=13.89$, $p<.001$, and the interaction of Contrast and Proficiency level , $F(45, 555) = 2.19$, $p < .001$. A Tukey's *post hoc* test found that there was a significant difference ($p < .05$) between the native Russians and all three proficiency levels. The Beginners were also significantly different from the other three groups, but the Intermediates and Advanced learners were not significantly different from each other.

A series of separate ANOVAs examining each contrast as a dependent variable found that there was a significant difference ($p< .05$) among the four proficiency levels for only 6 contrasts: /ʃ/ vs /ɕ/, /l/ vs /r/, /lʲ/ vs /l/, /pʲ/ vs /bʲ/, /fʲ/ vs /f/, and /rʲ/ vs /r/. *Post hoc* Tukey's tests showed that except for the case of /l/ vs /r/, there was a significant difference only between the NR group and the Beginner group for each contrast ($p < .05$). In the case of /l/ vs /r/, there was a significant difference between the NR group and the Intermediate group as well as the Beginner group. These results seem to show that no sound contrasts remained a problem for the Advanced learners of Russian. However, another perception task focusing more specifically on the /l/ vs /r/ contrast (reported in Larson-Hall, 2001) showed that scores on this contrast did not increase over proficiency or time. Both the statistics and the numerical results show that /l/ vs /r/ is the most difficult contrast for the Japanese learners. Although the statistics indicate that performance on the other 5 contrasts is only significantly different between the Beginner group and the NR, the numbers show us that the /ʃ/ vs /ɕ/ contrast is more difficult for learners than the four remaining contrasts. If the results of all the contrasts are conflated to information just about the 8 segments that were examined in this study, a (4) Proficiency Level x (8) Sound ANOVA found significant main effects for sound, $F(7, 259) = 22.49$, $p<.001$, Proficiency Level, F(3, 37=12.51, $p<.001$), and the interaction of the segment and proficiency level factor, $F(21, 259) = 3.05$, $p<.001$. A Tukey's pairwise comparison of the eight segments found that Japanese learners did significantly worse on /l/, /r/ and /ʃ/ than the other 5 segments ($p < .001$).

6. Discussion

The results found in this experiment can be taken as a partial confirmation of the predictive power of the Featural Model of L2 Perception. Recall that the FM predicted that Japanese learners would have difficulties with two contrasts: /l/ vs /r/ and /ʃ/ vs /ɕ/. We saw that these two contrasts were the most difficult for the learners in term of their numerical results. However, the FM predicted that because the feature that differentiates the contrasts is missing from the learner's L1 inventory, these contrasts should have remained problematic over all proficiency levels or years of schooling. This prediction was not borne out for this experiment.

Another discrepancy between the FM's predictions and the results found here is that four more contrasts were found statistically to differentiate learners in the early stages from native speakers: /lʲ/ vs /l/, /pʲ/ vs /bʲ/, /fʲ/ vs /f/, and /rʲ/ vs /r/. The predictions of the FM are absolute and do not explain any 'partial' problems with perception because the model predicts that if learners' underspecified inventory of features doesn't contain one of the features that differentiates a contrast in the L2, learners will not be able to perceive the difference between two phonemes in the L2. However, Brown (2000) has addressed this issue, and says that when a feature is missing from the inventory, perception will be blocked, but when the feature is available, it may be the case that it will take the perceptual system some time and development to establish a new phonological category. Brown found that with Japanese learners, perception of the English /ɹ-l/ contrast remained low for both low and high proficiency level learners, but that perceptual ability increased for the /b/ vs /v/ contrast between the two groups. Notice, however, that Brown does not propose any way to predict which contrasts may initially take some time to be able to perceive, so we may say that the existence of some contrasts which proved difficult for beginning learners of Russian cannot say anything one way or the other about the effectiveness of the model.

The real problem of this data for the FM is not that there are some contrasts which are found to be difficult for beginning learners that were not predicted by the model, but that the two contrasts which should theoretically pose longstanding problems for the learners did not turn out to do so. To be fair though, these two contrasts were the most difficult for the learners out of all the contrasts tested, so that the model was accurate in pointing to those areas that would cause the learners the most problems. It is possible that the type of task used here (4IAX-dual pair discrimination) was perceptually easier for the learners than other types of tasks that have previously been used in L2 perception research, such as the AX task (2-item discrimination: is X the same or different from A?) or ABX task (3-item discrimination: is X the same as A or B?), and this is why higher results were seen.

Flege's SLM made predictions about the level of difficulty certain sounds would present for Japanese learners. Recall that the SLM predicted that the 'similar' sounds [ʃ] and [ts] would be difficult for Japanese speakers, while the 'same' sounds [pʲ] and [mʲ] would pose no problem. It was also predicted that the 'new' sounds [l], [r], [ʒ], and [f] might cause trouble initially but would eventually be learned by Japanese speakers.

It was found that [l], [r] and [ʃ] were statistically more difficult for the beginning Japanese speakers than any of the other sounds, but these sounds did not remain problematic for more advanced learners. This fits in well with the prediction that [l] and [r] would be 'new' sounds and eventually learned, but presents a problem with the sound [ʃ], which was predicted to be a 'similar' sound, and difficult even for advanced learners to acquire. Also [ts] was predicted to be a 'similar' sound and pose longstanding problems for learners, but it did not seem to cause any trouble at all for any learners.

The fact that this experiment showed that *no* segments remained statistically difficult for advanced learners is also a problem for the SLM, because it also predicts longstanding problems with some segments but none are found. However, if we say that the sounds found to be the most problematic for learners given the data set were either the contrasts /ʃ/ vs /ɕ/ and /r/ vs /l/ or the segments /r/, /l/, and /ʃ/, no approach of the SLM comes close to predicting that precisely these sounds will be problematic. In fact, in all SLM approaches /r/ and /l/ are judged to be 'new' segments that will not cause longstanding problems, but these sounds (or this contrast) seems to be precisely the biggest problem. This prediction meshes well with the statistical results of the experiment performed here (that /r/ and /l/ do not remain problematic), but another experiment conducted with these same learners using a different perception task seems to indicate that /r/anḍ /l/ *do* remain longstanding problems in perception. This result seems to also fit well with other research that shows Japanese learners have outstanding problems differentiating between /ɹ/anḍ /l/ in English (Goto, 1971; Logan, Lively and Pisoni, 1991; Mochizuki, 1981; Sheldon & Strange, 1982; Takagi, 1993).

Of course, one may simply stipulate that [l], [r] and [ʃ] are 'similar' sounds (if one suspects that with different tasks the /ʃ/ vs /ɕ/ and /r/ vs /l/ contrasts will remain problematic for learners, which I do), and thus will be difficult for learners to accurately perceive, and that the rest of the segments are 'same' sounds and do not present any difficulties for learners (although this approach would still not provide any clues as to why some contrasts involving palatalization cause beginning learners some statistically significant problems). However, I believe this begs the issue, which is not to classify difficulties after the fact, but to predict the problems before they are found.

7. General discussion and conclusions

The results of the experiment showed that neither the Featural Model of L2 Perception or Flege's Speech Learning Model were totally accurate in predicting which sounds would be problematic in perception for Japanese learners of Russian. However, the FM correctly indicated which 2 out of 16 contrasts would be the most difficult for Japanese learners of Russian, while the SLM both underpredicted and overpredicted problems. Both of the models tested here are contrastive analyses in a way—they predict that some kinds of differences between the L1 and L2 are at the root of the learner's phonological problem, and as such, they are ideas that have been enticing us for a long time to find solutions. It seems to me that what is needed now is not a model like the SLM, which has not clearly delineated how best to implement its predictions and which, if it works at all, works best at the *a posteriori* level. We have also already tried and failed with theories which base predictions at the level of the phoneme or allophone. The Featural Model of L2 Perception makes clearly testable predictions, is based on a generative view of language and the view of a phoneme as an abstract entity built of features, and was highly suggestive of the problem areas encountered in this study. If it can be shown to be clearly predictive of problem areas in segmental phonology for many language pairings, then we may assume that the FM provides a good explanation of why learners have differential perceptual abilities in an L2. It is time to do more research to see whether the FM can better explain the way that L2 learners perceive segments.

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