HOW DO NATIVE SPEAKERS OF JAPANESE DISCRIMINATE AND CATEGORIZE FRENCH /r/ AND /l/ ?

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ABSTRACT
Japanese listeners have difficulty in perceiving the English /r/-/l/ contrast. Is the difficulty due to the absence of a parallel phonemic contrast in Japanese? In this paper, we examined whether Japanese also encounter difficulties in processing the French /r/-/l/ contrast. Japanese listeners with a limited exposure to French encountered little qualitative difficulty, compared to French, in discriminating French /r/-/l/ in natural stimuli. In an open-response identification test, Japanese consistently interpreted the French /l/s but not /r/s as a Japanese /r/, applying various transcriptions to French /r/s. This pattern was clearest for Japanese with no exposure at all to French. The identification data were consistent overall with the discrimination data: those items that were difficult to discriminate often received identical transcriptions. The results suggest that perception of non-native contrasts is partly determined by the detailed phonetic properties of the sounds involved, not solely by the specific structure of the native phonological system.

1. INTRODUCTION
Perception of nonnative phoneme contrasts is influenced by the sound system of the listener's native language. Two main accounts of cross-language speech perception are currently proposed. The classic account posits that nonnative phones are interpreted along the lines of the listener's native *abstract* phonological system. More recently, models of cross-language perception have proposed to take into consideration acoustic-phonetic details of realizations of both native and nonnative phones to account for the observed patterns in perception. One of those, Best's perceptual assimilation model (PAM, [2]) is partly based on the Articulatory Phonology developed by Browman and Goldstein.

A classic example of perceptual difficulties in processing nonnative phones is that of Japanese listeners with the American English /r/-/l/ contrast. Whereas the perception of synthetic English /r/-/l/ continua is categorical for American listeners, it is rather continuous for Japanese listeners [9, 10, 11]. The difficulties encountered by Japanese with /r/-/l/ depend on the context [6, 10], and can be partly overcome through training in English [7, 8, 11, 12]. It has also been reported that Japanese listeners tend to identify English /r/ as /w/-like [3, 10, 12].

From the viewpoint of abstract phonology, the Japanese difficulty with English /r/-/l/ is explained simply by the absence of a /r/-/l/ phonemic contrast in the Japanese phonological system. (Japanese has an /r/ but no /l/.) On this view, Japanese should encounter the same difficulty with /r/-/l/ contrasts from other languages than English, even though the detailed phonetic properties of these /r/s (and /l/s) notably differ from those of English /r/ (and /l/).

According to a "realistic" phonology account, the difficulty is partly due to the fact that there is no good match (in terms of articulatory-phonetic properties) between any sound of the Japanese repertoire and either English /r/ or /l/. Hence, this account leaves open the possibility that a different pattern of difficulty be observed with phonetically different /r/s and /l/s, such as French /r/s and /l/s.

In this study, we explored the capacity of Japanese listeners to perceive and categorize the French /r/-/l/ contrast. French /r/ is usually realized as a uvular approximant (often fricated); it is acoustically characterized by F1 lowering [1, 4, 5]. (American) English /r/ is usually a frictionless "bunched" /r/ (less frequently, it may be a retroflex approximant) and is acoustically characterized by a marked F3 lowering. As for the Japanese /r/, it is yet another, quite different, rhotic sound, usually realized as an alveolar tap. French /l/ is similar to English "light" /l/. However English /l/, not French /l/ includes some raising of the tongue dorsum and sounds "darker." In short, the French /r/-/l/ contrast is quite different from the English one.

In order to assess the possible difficulty of Japanese listeners with French /r/-/l/, we compared Japanese and French listeners' performance on a discrimination task, using natural stimuli systematically varied with respect to phonetic context. We then attempted to understand how Japanese listeners could interpret the French /r/s and /l/s using an open-response identification task run on two Japanese groups differing by their exposure to French: utterly naive vs. little exposed.

2. EXPERIMENT 1: DISCRIMINATION
This experiment examined Japanese listeners' discrimination performance using an AXB procedure with natural stimuli.

2.1. Method
Twelve Japanese aged 25 to 39 years, living in Paris but with little exposure to French (they first came to France a few months to a few years ago) participated in the experiment. For comparison, eight French participants aged 24 to 48 years were also tested. All of them volunteered to participate and reported no known speaking or hearing problem.

The materials consisted of 18 mono- or bi-syllabic items. Each item combined one liquid consonant, /l/ or /r/ in initial, medial, or final position, with the vowel context /a/, /i/, or /u/.

For example, there were three items with /r/ combined with /a/: /ra/, /ara/, and /ar/. Two native speakers of French (one male
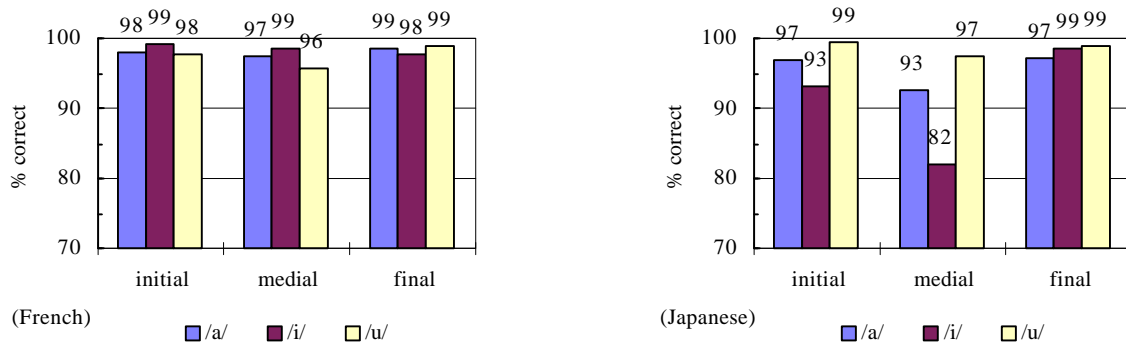
Figure 1. Rates of correct discrimination for Japanese and French participants, according to consonant position and vowel context.

and one female) pronounced eight tokens of each item. For each speaker, four tokens per item were retained, with the aim of avoiding systematic correlation between non segmental cues and consonant identity.

The 72 stimuli retained for each speaker were arranged in AXB triplets so that each item pair occurred eight times for each of the four AXB combinations. This produced, for each speaker, a total number of 288 AXB trials, randomly presented in 24 blocks of 12 trials. These 288 trials were preceded by 12 training trials. Participants were randomly assigned to the female speaker condition or the male speaker condition.

Participants were tested individually in a sound-attenuated booth. On each trial, the participant was presented with three stimuli and had to indicate whether the second item (X) matched better the first or the third stimulus, by depressing, as quickly as possible, one of the two response keys labeled "1" and "3." The intertrial and interblock intervals were 4 s and 9 s, respectively; the interstimulus interval was 1 s. RTs were measured from the onset of the /l/ or /r/ sound in the third stimulus of each trial.

2.2. Results

2.2.1. Rate of correct discrimination As can be seen in Figure 1, French participants performed almost at ceiling level (98% correct in average) whatever the consonant position or the vowel context. Japanese slightly differed from French participants especially in their lower discrimination performance of /iri/ vs. /ili/ (82% correct in average). These observations were substantiated by statistical analyses. We first examined the possible effects of Speaker (male vs. female) and of Trial type (X=A vs. X=B). These variables had no significant effect for either French or Japanese participants. The data was thus entered in a Language (French vs. Japanese) x Vowel-Context (/a/, /i/, and /u/) x Consonant-Position (initial, medial, and final) ANOVA, ignoring the other variables.

The effect of Language was marginally significant overall, $F(1, 18) = 4.0$, $p = .058$, indicating that the Japanese performance was only slightly below the French one. The difference between French and Japanese was actually limited to the consonant medial Position, $F(1, 18) = 6.02$, $p = .023$, and the vowel /i/ Context, $F(1, 18) = 9.02$, $p = .0075$. Neither Context nor Position had any effect at all for French participants, whereas these variables had a highly significant effect for Japanese, $p <$

.003; they performed at a lower level for medial Position, for /i/ Context, and at the lowest level for the /iri/ vs. /ili/ contrast.
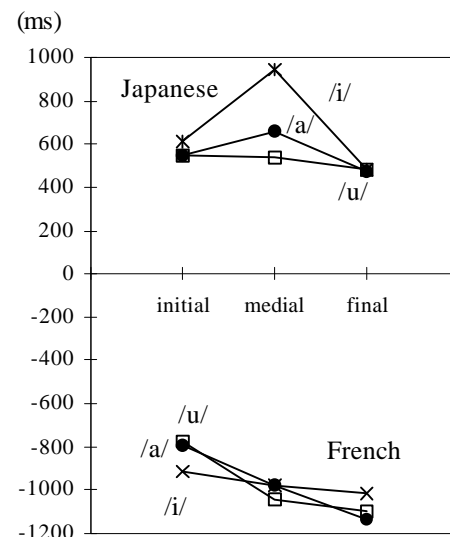

Figure 2. Discrimination RT data for Japanese (positive RTs) and French (negative RTs) participants.

2.2.2. Reaction times The difficulty encountered by Japanese listeners in discriminating French /r/s and /l/s was dramatically apparent in the RT data (Figure 2). As a rule, French listeners were able to respond in most trials even before the third stimulus was presented. Hence, because RTs were measured from the consonant onset in the third stimulus, French RTs were generally negative (mean -971 ms). Such was not the case for Japanese, whose RTs were rarely negative (mean 587 ms): they generally needed the third stimulus to respond. Their RT data strikingly paralleled their qualitative performance: the correlation between mean RTs and mean error rates in the nine comparison pairs was highly significant, $r(7) = .97$, $p < .0001$. This suggests that RT is a reliable and very sensitive measure of discrimination difficulty in the AXB paradigm.

The RT data were entered in a variance analysis, with the same variables as for the rate of correct discrimination data. The

difference in RT between French and Japanese listeners (Figure 2) was highly significant, $F(1, 17) = 111.0$, $p < .0001$. For French participants, the only significant effect was that of consonant Position: RTs decreased from the initial to the final position as could be expected for anticipated responses, since RTs were measured from the consonant onset in the third stimulus. For Japanese participants, whose responses were rarely anticipated, RT correlated with discrimination error rate: RTs were longer for the medial position and the /i/ context, and indeed were the longest for the /iri/ vs. /ili/ contrast (940 ms).

2.3. Discussion

The results obtained in the discrimination task call for two conclusions. First, the Japanese performance only slightly differed from the French one in terms of response accuracy. The lower level of performance of Japanese listeners was actually limited to those items in which the liquid occurred in medial position, and especially for the /i/ vowel context. At any rate, this does not support the predictions of a model of cross-language perception based on abstract phonology; rather, the capacity to discriminate /r/-/l/ shown by Japanese listeners appears to be modulated not only by the specific language to which these phones belong ([10] vs. this study), but also on the specific phonetic context with which they are combined.

Second, tiny differences in discrimination accuracy become dramatically apparent in the RT data. However, this seems to hold only for the differences that reflect real variations in discrimination difficulty: Japanese RTs were closely correlated to discrimination error rates, but such was not the case for French RTs, whose variations reflected differences in reference location for RT measurement. Indeed, the variables that affected the Japanese performance had no effect on the French performance.

Why, then, was the /iri/-/ili/ contrast the most difficult one for Japanese listeners? Experiment 2 partly addressed that issue.

3. EXPERIMENT 2: IDENTIFICATION

Those contrasting items that were difficult to discriminate should conceivably be labeled identically in an identification test. This experiment used an open-response identification test to relate the discrimination data to direct interpretations of the stimuli.

3.1. Method

The 12 Japanese participants in Experiment 1 also participated in Experiment 2. Another group of 15 Japanese students (aged 21-22 years) at Chiba University, who had never been exposed to French volunteered to participate in this experiment. All of them reported normal speaking and hearing. We hereafter refer to these two groups as J1 and J2, respectively.

The two sets of 72 stimuli selected for Experiment 1 provided 144 trials randomly presented in 12 blocks of 12 trials (interblock and intertrial intervals: 9 s and 4 s respectively).

The participants were tested individually in a quiet room. They received the stimuli through headphones at a comfortable listening level. For each trial, they had to write what they heard, using the katakana script, which is used in Japanese to transcribe, among other things, foreign names. Note that both the hiragana and katakana scripts are phonemically consistent, that is, each kana has a unique phonemic value. For example, the kanas of the "R-series" transcribe a CV syllable whose onset is the Japanese /r/ (alveolar tap) and the rime is one of the five Japanese vowels /a/, /u/, /i/, /e/, or /o/. Kana transcriptions can thus be readily interpreted in terms of their Japanese phonemic value, hence, of their phonetic value.

3.2. Results and discussion

Both J1 and J2 participants almost exclusively used R-series kanas to transcribe the French /l/ items (J1: 99.3%; J2: 97.9%). This suggests that Japanese listeners readily assimilate French /l/ to Japanese /r/.

By contrast, the French /r/ items were transcribed with other kanas a surprisingly large proportion of the time, excepted with the /i/ context, for which the *RI* kana was predominantly used (Figure 3). J2 participants used R-series kanas for French /r/ much less often than J1 participants, even with the /i/ context. For the /a/ context, participants of both groups often used *HA* ([ha]) in their transcription of /ra/ items (J1: 53%; J2: 66%) and even of /ara/ items (J1: 62%; J2: 80%); they used the vowel lengthening sign ([:]) for /ar/ items (J1: 45%; J2: 63%). For the /u/ context, participants of both groups often used *HU* ([fu]) in their transcription of /ru/ items (J1: 38%; J2: 74%) and also of /uru/ items (J1: 8%; J2: 75%); they used the vowel lengthening sign or the *O* kana ([o]) for /ur/ items (J1: 32%; J2: 50%). Interestingly, J2 (but not J1) participants also used *HU* (42%) in their rendition of French /r/ in /ir/. To sum up, these transcriptions suggest that Japanese categorized French /r/ as a Japanese /r/ when it was followed by /i/, but often as Japanese /h/ when it was followed by /a/ or /u/.

These results are consistent with the variable difficulty in discriminating French /r/-/l/ according to vowel context and consonant position. Specifically, for /r/ followed by /i/, Japanese listeners categorize it as Japanese /r/, however bad an exemplar of /r/ it may be. Hence, with the /i/ context, French /r/ is more often confused with /l/, because /l/ is consistently categorized as Japanese /r/. How could this vowel context effect be explained ? We suggest that Japanese speaker/listeners have some trouble to transcribe /ri/ with a kana of the H-series, as they often do for French /ra/ or /ru/, because the *HI* kana is pronounced with a palatal fricative onset and /i/, a syllable which has no posterior articulation component apt to render the uvular French /r/.

Although J1 Japanese have had little experience with French, they nonetheless had to learn some French, spoken and written, and had perhaps begun to associate the French sound /r/ with the letter 'r'. In the Japanese romaji script, 'r' precisely renders the Japanese /r/ sound. Hence, the J1 participants might have been biased by their knowledge of French spelling, however superficial that knowledge may be. On the other hand, the J2 participants were totally naive with respect to French sound-spelling associations and could not possibly be biased by spelling. Hence, J2 listeners used R-series kanas less often than J1 listeners in transcribing French /r/. As the ease for discriminating French /r/ and /l/ appears to be related to categorizing French /r/ as a different sound from Japanese /r/, we may surmise that J2 participants would have performed better than J1 participants in the discrimination test.
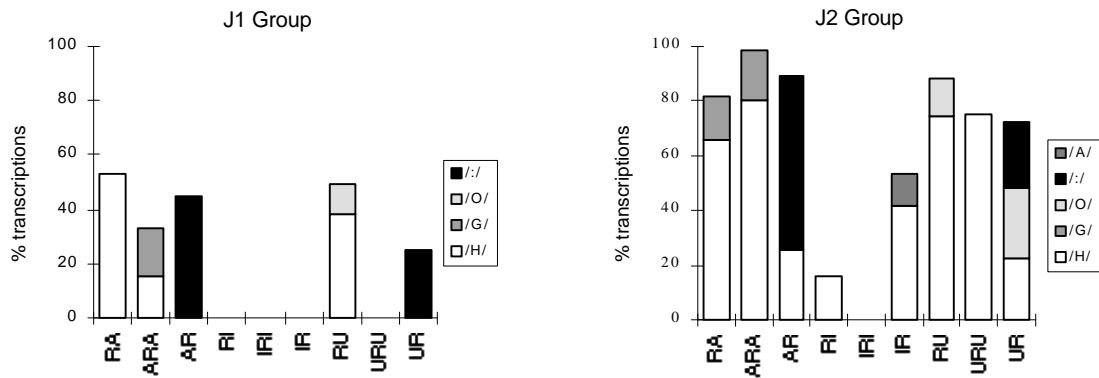
J1 Group

% transcriptions

Legend: ■ /:/ □ /O/ ■ /G/ □ /H/

X-axis: RA ARA AR RI IRI IR RU URU UR

J2 Group

% transcriptions

Legend: ■ /A/ ■ /:/ □ /O/ ■ /G/ □ /H/

X-axis: RA ARA AR RI IRI IR RU URU UR

Figure 3. Japanese transcriptions of French /r/ items with non R-series kanas.

4. GENERAL DISCUSSION

The results of Experiment 1 show that the French /r/-/l/ contrast, unlike the "parallel" English contrast, is relatively easy to perceive for Japanese listeners. This is difficult to explain in terms of an abstract phonology: since the French and English contrasts are structurally equivalent, Japanese listeners should encounter the same difficulty for French as for English. Moreover, an abstract phonology account cannot easily accommodate for the fact that discrimination performance varies systematically according to vowel context and consonant position. It thus seems reasonable to consider that discrimination performance is modulated by the detailed phonetic-acoustic properties of the speech sounds involved in a nonnative contrast, as proposed, for example, in PAM [2].

In Experiment 2, we attempted to describe how Japanese listeners perceive the French sounds /r/ and /l/ in terms of Japanese native categories, according to their position and according to their vowel context. Clearly, French /l/ is assimilated by Japanese listeners to Japanese /r/, whereas the case of French /r/ is less clear-cut. It seems, however, that this sound is consistently assimilated to Japanese /r/ only when followed by /i/. When followed by /a/ or /u/, there is a substantial trend toward an assimilation to Japanese /h/.

In the framework of the PAM model, French /r/-/l/ could be viewed as a "category-goodness" (CG) contrast: /l/ is treated as an acceptable exemplar of the Japanese tap /r/, whereas /r/ is treated as a poor and unstable exemplar of Japanese /r/, which may be heard as /h/ in certain phonetic contexts. In such occurrences, French /r/-/l/ could thus rather be close to the "two-category" (TC) type of contrast proposed by PAM. However, because Japanese /h/ articulatory-phonetic realization varies according to vowel context, additional identification tests are needed to draw an exhaustive picture of French /r/-to-Japanese /h/ assimilations. At any rate French /r/-/l/, whether CG or TC, differs from English /r/-/l/, which has been proposed to be a "single-category" (SC) contrast for Japanese [3], with both English /r/ and /l/ assimilated as (probably poor) exemplars of either Japanese /r/ or /w/ (also see [12]).

In conclusion, the present study supports the view that perception of nonnative phones and phone contrasts is not solely driven by the specific structural properties of the native and the nonnative phonemic systems. More accurate and predictive accounts of the patterns of cross-language perception should be based on a realistic phonology, grounded on the reality of speech production, that is, on the specific phonetic-articulatory properties of speech sounds.

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