THE PERCEPTION OF AMERICAN ENGLISH APPROXIMANTS BY FRENCH NATIVE SPEAKERS

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ABSTRACT

Speakers of Japanese (and other Asian languages) have trouble perceiving the American English (AE) /r/-/l/ "liquid" contrast. The difficulties they encounter are often explained by the specific structural contrasts of their native phonological systems, which do not include a phonemic distinction paralleling AE /r/-/l/. Accordingly, speakers of languages such as French which *do* possess that phonemic distinction should encounter little difficulty in perceiving the AE /r/-/l/ contrast. However, from an articulatory-phonetic standpoint, French and AE /r/s have little in common, suggesting that French listeners may have difficulty categorizing AE /r/s. The present study examined identification and discrimination of the AE continua /r-l/, /w-r/, and /w-j/ by French participants. French listeners did encounter difficulties with AE /r/, which they tended to hear as /w/-like. We propose that the detailed articulatory-phonetic properties of the sounds involved, not solely their abstract phonological status, account for the observed perceptual patterns.

1. INTRODUCTION

Adults' perception of speech segments is highly constrained by experience with the phonological system of their native language. The notion of a "phonological filter" [12] seems to be an apt metaphor for the presumed linguistic structural source of the difficulties in perceiving and producing nonnative phones: nonnative phones are interpreted along the lines of the listener's native phonological system. Accordingly, the phonetic contrasts that are not employed contrastively in the listener's language should be difficult to discriminate or produce. A classical example of perceptual difficulties with nonnative phones is that of Japanese listeners with the AE /r/-/l/ contrast [2, 10, 11, 15]. According to phonologically-based accounts, the difficulty has been explained by reference to a crucial phonological difference between English, which maintains a contrast between /r/ and /l/, and Japanese, whose phonological system includes an /r/ but no /l/. It is specifically because Japanese lacks an /r/-/l/ phonological contrast, the classic argument goes, that Japanese listeners have difficulty discriminating the phonetic distinction.

On a different account, cross-language difficulties with nonnative phones are determined not only by the abstract phonological functions of speech segments but also by their specific phonetic-articulatory realizations [9]. Best's Perceptual Assimilation Model [1], for example, suggests that perceptual assimilation of unfamiliar nonnative speech contrasts is based not only on the abstract structural properties of the native phonological system, but even more fundamentally on phonetic-articulatory relations between similar native and nonnative phones. That suggestion can be evaluated directly by examining the perception of AE /r/-/l/ by listeners whose native language *does* have a parallel phonological contrast, but in which the phonetic details of those consonants are notably discrepant from the English ones. Those phonological and phonetic conditions are met by French. AE and French /l/s are similar (excepted that AE /l/, not French /l/, includes some raising of the tongue dorsum in the velar region [4]) but French /r/ is usually an uvular approximant [5, 6] that is often fricated, whereas AE /r/ is usually a frictionless "bunched" /r/, or less frequently, a retroflex approximant [6, 3].

On an abstract phonological view, French listeners should have little or no difficulty in processing AE /r/, which could be readily assimilated to French /r/. A different prediction can be made by a phonetically-articulatorily motivated account. These contrasted predictions were tested in the present study by running French listeners on synthetic AE approximant continua. In order to compare the results with a previous study of Best and Strange [2], the same materials and procedure as in [2] were used. This also allowed to test French listeners not only on the AE /r/-/l/ continuum, but also on /w/-/r/ and /w/-/j/.

2. EXPERIMENT 1

This experiment examined French listeners' performance in discrimination and two-choice identification tests on three AE continua: /w/-/j/, /r/-/l/, and /w/-/r/.

2.1. Method

The materials described in detail in [8] and [2] (ten-step /rak/-/lak/, /wak/-/rak/, and /wak/-/jak/ continua) and the same procedures as in [2] were used, so that we could compare the performance of French listeners to that of Americans and Japanese on the same materials and procedures. Participants were run in three sessions, each session corresponding to one of the three continua. In each session, participants first completed a two-choice identification test, then an AXB discrimination test on the same series. They were tested individually in a sound-attenuated booth. After completion of the two tests, participants were asked to write their responses to a posttest questionnaire, including an informal description of the sounds they heard.

The identification tests consisted of 20 blocks of 10 trials, presented in random order. Each stimulus was thus presented 20 times. The intertrial and interblock intervals were 2.5 s and 4 s respectively. For each trial, the participants had to circle one of two letters on an answer sheet (e.g., 'W' or 'Y' for the /w/-/j/ series) to indicate the initial consonant they heard.

The discrimination task was a 3-step AXB procedure. Along each 10-step series were seven pairs of stimuli differing by three steps. Each pair was repeated 5 times for each of the 4 possible AXB combinations. There was thus 140 trials, presented in random order, in 14 blocks of 10 trials (intertrial and interblock intervals: 3 s and 6 s, respectively; within-trial interstimulus interval: 1 s). For each trial, the participant had to circle the number "1" or the number "3", to indicate whether the second item (X) matched the first or the third item of the trial.

Fifteen French university students participated in this study (M = 22.8 years, range = 19-27 years) for payment. All reported little to no spoken English experience with native speakers of American or British English. None reported hearing, or speaking problems. Five additional participants were tested but removed from the final data-set, two for failing to complete all three tests, one for having lived 6 months in the USA, one whose first language was Vietnamese, and one whose responses on all tests were near or at chance level.

2.2. Results and discussion

2.2.1. Identification. For the /w/-/j/ series, but also for /r/-/l/, the pooled identification functions suggest that French listeners' performance was similar to that of American listeners, but they performed rather poorly as a group for /w/-/r/ (Figure 1)

Best fit ogives of individual identification functions were estimated by using narrow range PROBIT analyses (see [2]), allowing for the computation of individual category boundary location (intercept) and steepness of identification function at boundary (slope), which indexes identification accuracy. The results for the French participants in the present study and the American ones in [2] are summarized in Tables 1 and 2. Note that for /w/-/r/, intercept and slope could not be computed for five participants because their identification function did not cross the 50% level: these participants dominantly responded 'W' throughout the entire continuum. (One of them gave 100% 'W' responses throughout the entire continuum.) The remaining available intercept and slope data were compared between French (this study) and American (in [2]) listeners.

	/w-j/			/r-l/			/w-r/		
	N	*M*	*SD*	N	*M*	*SD*	N	*M*	*SD*
Fr.	15	4.85	(1.29)	15	4.88	(0.81)	10	5.68	(0.62)
Am.	9	5.36	(1.06)	9	5.38	(1.01)	9	4.84	(0.70)

Table 1. Identification intercepts for French vs. Americans: number of participants, mean (stimulus #), standard deviation.

	/w-j/			/r-l/			/w-r/		
	N	*M*	*SD*	N	*M*	*SD*	N	*M*	*SD*
Fr.	15	1.77	(0.59)	15	1.53	(0.43)	10	1.02	(0.45)
Am.	9	1.93	(1.03)	9	2.15	(0.73)	9	1.72	(0.69)

Table 2. Identification slopes for French vs. Americans: number of participants, mean (arbitrary), and standard deviation.

French did not differ significantly from Americans on the /w/-/j/ continuum, for either intercept or slope. For /r/-/l/, French and American listeners exhibited similar boundary location, but Americans had significantly steeper slopes (2.15 vs. 1.53), $F(1,22) = 6.93$, $p = .015$. Although the difference between French and Americans in /r/-/l/ boundary location was not significant, the trend was that French made fewer 'R' judgments than Americans did (45.5% vs. 50.2% 'R' responses overall). For /w/-/r/, the French listeners' performance differed sharply from that of Americans in two ways. Firstly, five French participants showed a "W-dominant" pattern of responses so that their intercept and slope data could not be estimated at all. Second, the data of the 10 remaining "two-category" French participants differed from that of American listeners for both intercept (5.68 vs. 4.84), $F(1,17) = 7.84$, $p = .012$, and slope (1.02 vs. 1.72), $F(1,17) = 7.24$, $p = .015$.

2.2.2. Discrimination. The discrimination data are shown in Figure 2. French were compared to Americans for their overall discrimination performance. A strong Language x Series interaction was found, $F(4,44) = 9.58$, $p < .0001$, reflecting the fact that Americans' performance was very homogeneous across
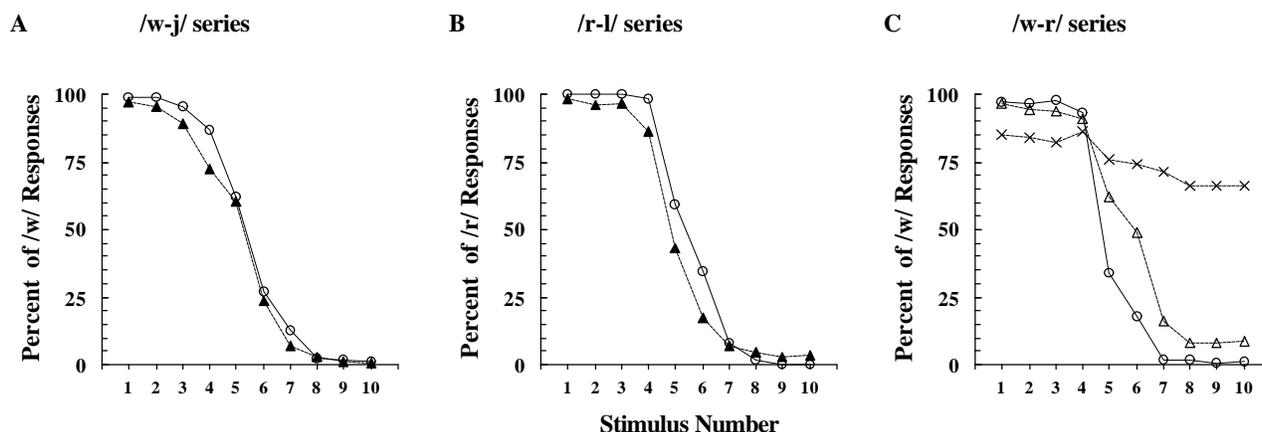
A   /w-j/ series   **B   /r-l/ series**   **C   /w-r/ series**

Figure 1. Identification data for French (triangles or x for "W-dominant") in this study, and for Americans (circles) in [2].

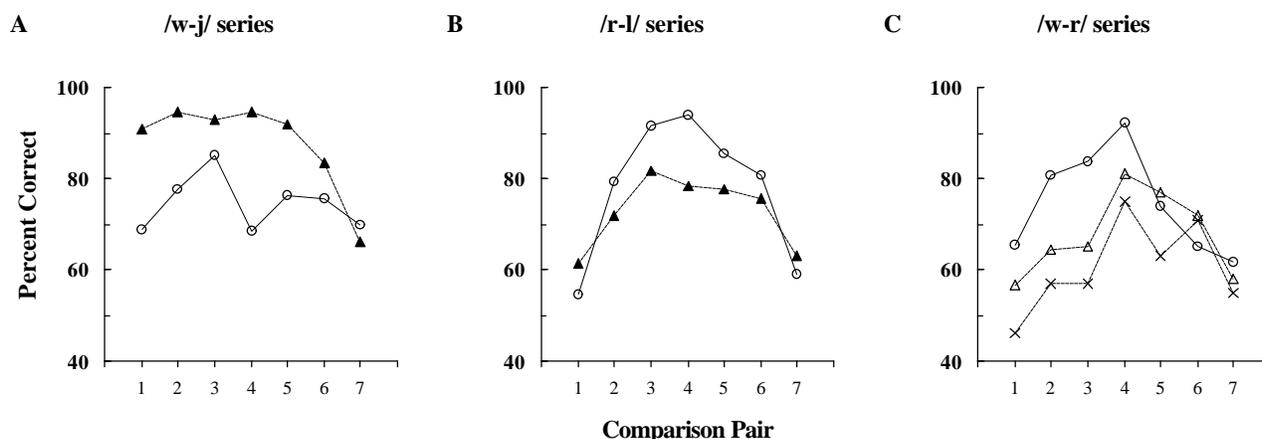**A** /w-j/ series **B** /r-l/ series **C** /w-r/ series

Figure 2. Discrimination data for French (triangles or x for "W-dominant") in this study, and for Americans (circles) in [2].

the three series (75% to 78% correct overall), while French performed at quite different levels according to series (/w/-/j/ >> /r/-/l/ > /w/-/r/). For the /w/-/j/ series, the French performance was higher than Americans, $F(1,22) = 16.15$, $p < .001$. For /r/-/l/, French participants performed almost at the same level as Americans. For /w/-/r/, the French performance was lower than that of Americans by about 10%, $F(1,22) = 8.65$, $p < .01$. The performance of the two-category subgroup tended to be better than that of the W-dominant subgroup for the /w/-/r/ series, $F(1,13) = 3.31$, $p = .089$, but not for the other series (Fs < 1).

The French data were also analyzed in a Series x Comparison Pair ANOVA. The effect of Series was highly significant, $F(2,28) = 60.14$, $p < .0001$: performance differed according to continuum. For the /w/-/j/ series, the general shape of the French discrimination functions was plateau-like (values close to 90%). differing from the clearly two-peak shape observed for both American and Japanese participants in [2], suggesting that these listeners heard intermediate segments in the /w/-/j/ series (/l/-like consonants for Americans). In spite of the difference in discrimination function shape, the French listeners' comments suggested that they also heard intermediate /l/-like consonants in the /w/-/j/ series, as Americans did. For the /r/-/l/ series, the shape of the French discrimination function was plateau-like rather than clearly two-peaked. The plateau-like region extended from the third to the sixth pair. Therefore, for this continuum, French and Americans differed qualitatively rather than quantitatively. Whereas the discrimination function of Americans showed a single peak roughly corresponding to their categorical boundary between /r/ and /l/, that of French listeners was plateau-like, similar to that found for Japanese listeners [2, 8 , 11, 15]. In contrast, the French discrimination function for the /w/-/r/ series had a single peak at pair 4.

Together, the results suggest that French listeners have some difficulty in perceiving the properties of AE /r/. Their difficulty is not as marked as that of "inexperienced" Japanese listeners in processing the /r/-/l/ continuum [2]. Still, compared to Americans, French listeners exhibited shallower identification functions for the continua involving /r/, and tended to report less 'R' overall, especially for the /w/-/r/ series. The difference is

also apparent in the discrimination performances for /r/-/l/ and /w/-/r/. The French data for the latter series are somewhat reminiscent of the Japanese data in [15], in which Japanese listeners, run on a three-choice identification task, reported an intermediate 'W' on the /r/-/l/ continuum much more frequently than American listeners did. This suggests that the AE /r/-/l/ continuum encompasses a third, /w/-like, category for Japanese listeners. Similarly, in AE /r/-/l/, French listeners reported hearing "intermediary" segments similar to /w/.

3. EXPERIMENT 2

The possibility that French listeners somehow assimilate AE /r/ as /w/-like motivated the second experiment, in which a third choice was available on the identification test for the /r/-/l/ continuum. For comparison with Experiment 2 in [2], we also examined whether French participants hear /l/-like consonants in the /w/-/j/ continuum. Given that French /l/ is similar to AE /l/, French listeners might well also label intermediate stimuli of the /w/-/j/ series as /l/. Experiment 2 thus consisted of two three-choice identification tests for the /r/-/l/ and /w/-/j/ continua and of the corresponding discrimination tests.

3.1. Method

The same /r/-/l/ and /w/-/j/ series and the same procedures as in Experiment 1 were used, excepted that a third choice ('W' and 'L', respectively) was included in the two identification tests.

Fourteen French university students (M = 25.6 years, range = 20-35 years) with no known speech problems participated in this study for payment. None of them had participated in Experiment 1. All reported little spoken English experience.

3.2. Results and discussion

3.2.1. Identification. For the /w/-/j/ series, the French data were essentially similar to that obtained for Americans in [2], Experiment 2. This confirmed that French, as well as Americans, heard an /l/-like sound in the /w/-/j/ series, in keeping with the suggestion that this phenomenon is due to the acoustic properties of the ambiguous stimuli. For the /r/-/l/ series, the results are somewhat less homogeneous. Out of 14

French participants, 10 divided the continuum into three clearly defined categories, with a /w/ category peaking to 63.3% at stimulus 5 (Figure 3). Two participants had a clear /l/ category but responded 'W' as often as 'R' in the /r/ portion of the continuum; two others had a clear /r/ category, but responded 'R' more often than 'L' before stimulus number 10, on which both response rates were similar.

3.2.2. Discrimination. For the /w/-/j/ series, the French performance was nearly at ceiling (94.2% correct responses). The shape of the discrimination functions was plateau-like (as in Experiment 1), with a weak trend for two wide peaks at pairs 2-3 and 5-6. This pattern is consistent with an intervening third /l/-like category in that series. For the /r/-/l/ series, the overall performance of French listeners was not different from that of Americans in [2], Experiment 1. At pairs 3 and 6, however, there were clear peaks of discrimination, significantly higher than the two surrounding values (pair 3: $F(1,13) = 22.68$, $p = .0004$; pair 6: $F(1,13) = 8.51$, $p = .012$).

To sum up, the results of Experiment 2 confirm that French listeners differ from Americans in their perception of the AE /r/-/l/ contrast. This difference is conceivably due to a tendency to interpret AE /r/ as a variant of /w/ (presumably, as a rather poor exemplar of a French /w/). This tendency is apparent from the /w/-/r/ and the /r/-/l/ data obtained in Experiments 1 and 2. As suggested by the French participants' comments, the third consonant category that they hear along the /r/-/l/ series is /w/, as for the Japanese run on a "right"-"light" continuum in [15].

4. DISCUSSION

Overall, the results suggest that French listeners, not unlike Japanese listeners, have difficulty perceiving AE /r/, which they tend to categorize as /w/-like. This trend is most clear in the case of the intermediate stimuli between /r/ and /l/ (when listeners are given the choices 'R,' 'W,' and 'L'), which happen to be acoustically closer to AE /w/ than the /r/ endpoint. Assimilation of AE /r/ toward /w/ is not too surprising, in light of reports on phonological development. Substitutions of /w/ for /r/ ("gliding") are especially common in English children [14] and misperception of /r/ as /w/ is not uncommon in three-year-olds [13]. Another indication of the difficulty inherent to /r/ is the large variability in its phonetic-articulatory realizations, both across and within languages [7], most notably English [6].

The French data in this study confirm our suggestion that in order to account for the organization of speech perception across languages, a realistic phonology should incorporate phonetic-articulatory descriptions of the segmental categories in each language. This kind of phonology, grounded on the reality of speech production, is proposed by the Articulatory Phonology developed by Browman and Goldstein. From the perspective of cross-language speech perception, this kind of phonology is more apt, we believe, to predict and explain the perceptual performance of native vs. nonnative speaker-listeners than are more traditional models based solely on phonological considerations.
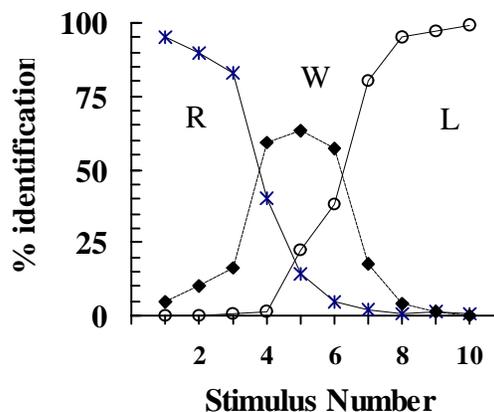

Figure 3. Identification data in Experiment 2 (10 subjects)

REFERENCES

[1] Best, C. 1995. A direct realist perspective on cross-language speech perception. In W. Strange & J. J. Jenkins (eds.), *Speech perception and linguistic experience: Issues in cross-language research*, (pp. 171-204). Timonium, MD: York Press.

[2] Best, C., and Strange, W. 1992. Effects of phonological and phonetic factors on cross-language perception of approximants. *Journal of Phonetics*, **20**, 305-330.

[3] Boyce, S., and Espy-Wilson, C. 1997. Coarticulatory stability in American English /r/. *Journal of the Acoustical Society of America*, **101**, 3741-3753.

[4] Browman, C., and Goldstein, L. 1995. Gestural syllable position effects in English. In F. Bell-Berti & L. Raphael (eds.), *Producing speech: Contemporary issues. For Catherine Stafford Harris*, (pp. 19-33). New York, NY: AIP Press.

[5] Delattre, P. 1969. L' R parisien et autres sons du pharynx. *The French Rreview*, **43**, 5-22.

[6] Delattre, P., and Freeman, D. 1968. A dialect study of American R's by x-ray motion picture, *Linguistics*. **44**, 29-68.

[7] Lindau, M. 1985. The story of /r/. In V. A. Fromkin (ed.), *Phonetic linguistics: Essays in honor of Peter Ladefoged*, (pp. 157-168). New York: Academic Press.

[8] MacKain, K., Best, C., and Strange, W. 1981. Categorical perception of English /r/ and /l/ by Japanese bilinguals. *Applied Psycholinguistics*, **2**, 369-390.

[9] Mann V. 1986. Distinguishing universal and language-dependent levels of speech perception: Evidence from Japanese listeners' perception of English /l/ and /r/. *Cognition*, **24**, 169-196.

[10] Miyawaki, K., Strange, W., Verbrugge, R., Liberman, A., Jenkins, J., and Fujimura, O. 1975. An effect of linguistic experience: The discrimination of [r] and [l] by native speakers of Japanese and English. *Perception & Psychophysics*, **18**, 331-340.

[11] Mochizuki, M. 1981. The identification of /r/ and /l/ in natural and synthesized speech. *Journal of Phonetics*, **9**, 283-303.

[12] Polivanov, E. 1931. La perception des sons d'une langue étrangère. *Travaux du Cercle Linguistique de Prague*, **4**, 79-96.

[13] Slawinski, E., and Fitzgerald, L. 1998. Perceptual development of the categorization of the /r-w/ contrast in normal children. *Journal of Phonetics*, **26**, 27-43.

[14] Snow, K. 1963. A detailed analysis of articulation responses of "normal" first grade children. *Journal of Speech and Hearing Research,* **6**, 277-290.

[15] Yamada, R., and Tohkura, Y. 1992. The effects of experimental variables on the perception of American English /r/ and /l/ by Japanese listeners. *Perception and Psychophysics*, **52**, 376-392.