

Between Perception and Production: Is the ability to hear L1-L2 sound differences related to the ability to pronounce the same sounds accurately?

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Abstract

It is well known that the English /r/-/l/ contrast is extremely difficult for Japanese speakers to perceive and produce even after many years of English education. This study examined how the ability to distinguish first language (L1)-second language (L2) sound differences relates to the ability to pronounce the sound accurately in second language acquisition. Native speakers of Japanese identified English /r/-/l/ contrast and other consonant contrast minimal pairs. The subjects' productions of minimal pairs were recorded, and a native speaker of American-English perceptually evaluated these productions. In this study, the perception and production abilities of 38 adult Japanese English learners were examined.

Key terms: World Englishes, English as a lingua franca, phonetic environment, perception, production

1. Introduction

The concepts of World Englishes and English as a Lingua Franca have become popular in the last few decades, and many linguists question the use of native speaker pronunciation models in English teaching. Some researchers argue that English learners should have ownership of English, and they do not need to attain native-like pronunciation (Higgins, 2003; Jenkins, 2000, 2002, 2005, 2006; McKay, 2002). The argument is that native speakers have different accents depending on the region where they were born and live. Therefore, the accents of speakers of English as a lingua franca (ELF) should be accepted in the same way. Pronunciation accuracy may not be so important where English is spoken as a lingua franca, which is used among people of different mother tongues, including native English speakers, for communication. In the ELF context such as Ritsumeikan Asia Pacific University, incorrect or ungrammatical usage is less problematic because being able to communicate is more important, and Jenkins (2000, 2002) argued that English learners do not have to adapt to native speaker norms. However, accuracy is still quite important because it may also cause misunderstanding and intelligibility problems (Jenkins, 2002). It would be ideal to make ourselves understood to interlocutors within contexts both where English is used as a lingua franca and where English is the primary language for communication such as North America, Australia, and Britain.

2. Literature Review

Although second language (L2) accents have been a topic of discussion in the field of second language acquisition for a long time, the study of pronunciation has been marginalized in the field of applied linguistics (Derwing et al., 2005). Much less research has been conducted on L2 pronunciation than on other areas such as grammar and vocabulary. Moreover, most of the studies on Japanese pronunciation were conducted in the past few decades, and there do not appear to be any recently studies.

The /r/ and /l/ identification

A Japanese accent is recognizable by the lack of /r/-/l/ distinctions (Major, 2001), and the difference between the liquid consonants /r/ and /l/ is one of the most well-known and well-documented examples of the difficulty that Japanese learners of English face in distinguishing sounds (Bradlow, et al., 1997, 1999; Goto, 1971; Iverson, et. al., 2003; McCandliss, et al., 2002; McClelland, et al. 2002; Miyawaki et al., 1975; Mochizuki, 1981). Several studies have been conducted to examine the identification of /r/ and /l/ (Goto, 1971; Miyawaki et al., 1975; Mochizuki, 1981). The /r/-/l/ contrast is not distinctive in Japanese phonology, and adult Japanese learners of English have great difficulty producing this contrast appropriately. They also have difficulty in perceptually differentiating these phonemes in minimal pairs from examples of natural speech in American English (Mochizuki, 1981). Both /r/

and /l/ are perceived as the same consonant by Japanese speakers (Miyawaki et al., 1975).

Training on the /r/ and /l/ identification

Earlier studies (Goto, 1971; Miyawaki et al., 1975; Mochizuki, 1981) focus on describing difficulties with the identification of /r/ and /l/. Later studies (Bradlow, et al., 1997, 1999; McCandliss, et al., 2002; McClelland, et al. 2002; Iverson, et. al., 2003) examined the effects of training adult Japanese speakers in /r/-/l/ perceptual identification. In Bradlow et al.'s (1997) study, the participants living in Japan improved their accuracy by 16% in /r/-/l/ identification after four weeks of training while the control group did not demonstrate any improvement. Although the 16% improvement is still substantially poorer than the near-perfect identification accuracy, researchers considered the results of the study to be a substantial improvement for their subjects. The study also showed that the Japanese speakers' production was improved after they received the training even though no production training was provided. A similar investigation on Japanese participants living in the United States conducted by McClelland et al. (2002) showed that feedback can have substantial effects on the outcome of learning.

The effect of age and individual experience

In addition to the phonetics, the time when Japanese start learning English may influence why they have difficulty perceiving and producing some L2 sounds appropriately. Studies of age-related effects on the L2 pronunciation have led researchers to conclude that L2 speech learning must occur during a critical period in order to be fully effective (Flege, 1987, 1999; Flege et al., 1997; Long, 1990; Major, 2001). The critical period hypothesis states that there is a specific developmental period during which it is possible to acquire a language, L1 or L2, to normal, native-like levels. Once this period has passed, the ability to learn the language declines (Birdsong, 1999). Long (1990) concluded that the ability to attain native-like phonological abilities in a second language begins to decline by the age of six, and the L2 is usually spoken with an accent if learning begins after the age of 12 years, and with variable success between the ages of six and 12. Japanese people start studying English as a foreign language at the age of 12-13 which is beyond puberty, and therefore beyond the critical period. This could be one of the reasons why Japanese EFL learners have problems with pronunciation.

Although it is widely accepted that this critical period has effects on phonological abilities, speech perception is altered by an individual's language experience (Zhang et al, 2005). Flege (1997) and his colleagues assessed the effect of the amount of L1 use on L2 pronunciation accuracy. The results suggest that the degree of activation of the L1 or the strength of its representations may influence L2 pronunciation. Given the language experience of Japanese EFL learners in Japan and their limited opportunities to use English in daily life, it is perhaps inevitable that their English is highly inflected with Japanese pronunciation.

3. Purpose of the study

Overall, existing data positively suggests that the mechanisms of language perception are not completely fixed in adulthood. However, studies on language production of Japanese English learners and the comparison of perception and production have not been conducted sufficiently. Therefore, the main purpose of this research paper is to report on an exploratory study that investigates the relationship between perception and production. I replicated Mochizuki's (1981) /r/-/l/ identification study for my perception test, and I developed a production test based on her perception study. The production test part of the study adapts the procedure of Bradlow et al.'s (1997) study which attempted to describe the relationship by comparing the Japanese participants' ability to perceive and their ability to produce non-native sounds, i.e. /r/-/l/ contrast.

In addition to /r/-/l/ contrast, "think" and "sink" pose a problem because the Japanese language lacks the sound for the English dental fricative /θ/. Japanese does not make phonemic distinction between the alveolar fricative /s/ and the dental fricative /θ/. The dental fricative /θ/ is a non-native sound to Japanese, so that Japanese learners of English tend to hear /s/ which is the closest Japanese sound (Cairns, 1988). The non-native sound /θ/ will be assimilated to the most similar Japanese sound and is often produced as /s/ by Japanese speakers. There are some other sounds that Japanese speakers have difficulties in discriminating between, and I included /s/-/θ/ and other sound contrasts such as /s/-/ʃ/ and /b/-/v/ for the present study. The other sound contrasts

will be explained more in the methods section.

This study seeks, first, to further the understanding of the difficulty in distinguishing the liquid consonant /r/ and /l/ according to their position such as initial position and initial consonant-cluster position, and second, to examine the difficulty in producing /r/ and /l/ phonemes according to their position. This study also seeks to examine the relationship between perception ability and production ability. Accordingly, the following research questions were posed:

1. How does the position of /r/ and /l/ in a word affect the ability to perceive these sounds?
2. How does the position of /r/ and /l/ in a word affect the ability to produce these sounds?
3. What is the relationship between perception ability and production ability?
 - 3 a. Does the ability to distinguish /r/-/l/, /s/-/θ/ and other sound contrasts lead to better pronunciation when producing the sounds?
 - 3 b. Conversely, does the better production ability to pronounce /r/-/l/, /s/-/θ/ and other contrasts result in better perception ability to hear the differences?

4. Method

Participants

The participants of this study are thirty-eight native speakers of Japanese (twenty-two females and sixteen males) attending Ritsumeikan Asia Pacific University (APU). They were first year university students and were enrolled in Elementary English at the time of data collection. Their language proficiency levels in English based on TOEFL ITP scores vary, ranging from 340 to 417.

Two native speakers of American English participated. One of them produced the minimal pair words for a perception test, and his utterances were recorded and stored on the CD. The other participant acted as the production test judge and evaluated Japanese participants' utterances. He is an English language teacher at APU and has lived in Japan for approximately one year at the time of data collection.

The general design of the present study had three phases: a perception test phase, a production test phase, and a production evaluation phase. This study adopts Mochizuki's (1981) identification test and Bradlow et al.'s (1997) production test procedure.

Perception test procedure

This perception test is a replication of Mochizuki's study (1981). I used /r/-/l/ stimuli that Mochizuki developed for her perception test and incorporated other minimal pairs. The Japanese participants listened to 100 words (50 /r/-/l/ and 50 other contrasts) in English minimal pairs; that is words that differ by only one phoneme, such as "rock/lock" and "sink/think." Specifically for /r/ and /l/, there are five categories according to their position: the initial position (e.g. "right" and "light"), the initial consonant-cluster position (e.g. "pray" and "play"), the intervocalic position (e.g. "berry" and "belly"), the final consonant-cluster position (e.g. "sort" and "salt"), and the final position (e.g. "tower" and "towel"). The English minimal pair words were produced by a male native speaker of American English. On the answer sheet, all the minimal pair words with /r/ are arranged in the left column and all the words with /l/ are arranged in the right column. Japanese participants were asked to circle the word they heard on the answer sheet.

All of the previous studies of consonant contrast have been focused on /r/-/l/ contrast. In the present study, in addition to /r/-/l/ contrast, I explored other consonant contrasts. The stimuli consisted of 50 words that contrast seven sets of phonemes: eight of the voiceless alveolar fricative /s/- the voiceless interdental fricative /θ/ minimal pairs, six of the voiceless alveolar fricative /s/- the voiceless alveopalatal fricative /ʃ/, eight of the voiceless labiodental fricative /f/- the voiced labiodental fricative /v/ minimal pairs, eight of the voiceless labiodental fricative /f/- the voiceless glottal fricative /h/ minimal pairs, eight of the voiced bilabial stop /b/- the voiced labiodental fricative /v/ minimal pairs, eight of the voiced interdental fricative /ð/- the voiced alveolar stop /d/ minimal pairs, and four of the voiced alveolar fricative /z/- the voiced interdental fricative /ð/ minimal pairs. These contrasts were chosen because they were considered 'difficult' for Japanese learners of English (Guion et. al., 2000; Uchida, 2008).

Production test procedure

I used the same minimal pairs from the perception test for the production test. The Japanese participants were asked to produce 50 words that contrast /r/ and /l/ in five phonetic environments as well as 50 minimal pair words with other sound contrasts. Japanese participants' utterances were recorded using software called Free Audio Recorder, and the data was stored in MP3 format for later presentation to a native speaker of English for evaluation.

Production evaluation

For the production evaluation, the Japanese participants' pronunciations were judged by a native speaker of English. The answer sheets were organized as in the perception test, and a "neither" option was added. The rater was asked to listen to Japanese participants' utterances and distinguish between the words given on the answer sheet and circle the words he heard. A mark was given only when the student produced /r/-/l/ correctly, and other aspects of pronunciation were ignored.

5. Results

Results of Perception Test

Table 1: Individual Japanese subject perception and production accuracy scores

Subject	/r/-/l/ perception	Other perception
1	43 (86%)	38 (76%)
2	38 (76%)	47 (94%)
3	37 (74%)	48 (96%)
9	39 (78%)	39 (78%)
19	40 (80%)	41 (82%)
36	41 (82%)	49 (98%)
13	26 (52%)	34 (68%)
22	26 (52%)	31 (62%)

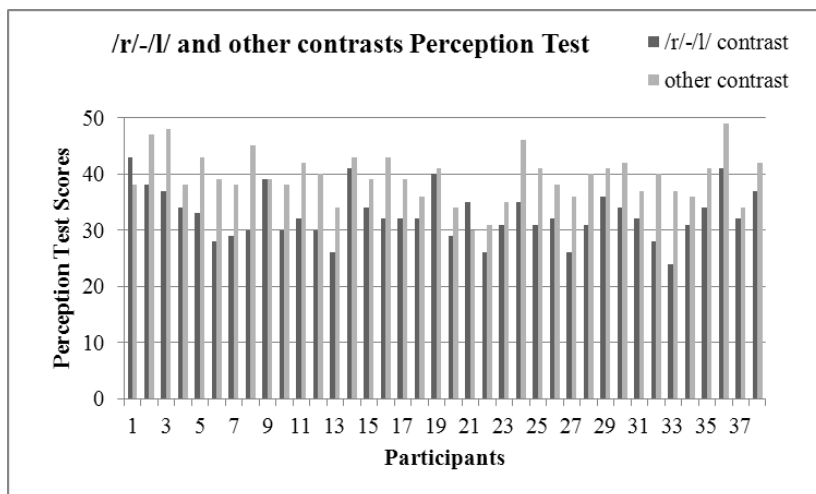


Figure 1: Perceptual identification performance for /r/-/l/ contrast and the other consonant contrasts

Table 1 shows the Japanese learners of English test scores and percentage for the /r/-/l/ perception test and other consonant

contrasts perception test. As can be seen in Table 1 as well as in Figure 1, most of the participants who could distinguish /r/-/l/ contrast were also able to distinguish other sound contrasts. Subject 1, 2, 3, 9, 19, and 36 achieved over 70% on both tests, and Subject 13 and 22 performed below 70% on both tests. Subject 1 and 21 performed better on /r/-/l/ perception test, and Subject 9 attained the same score on the /r/-/l/ and other contrast perception test, whereas all other participants performed better on the other consonant contrasts perception test. The number in the sample is only 38, which is not large enough to generalize the results. Thus, it may not be appropriate to make a generalization based on these results. However, the results suggest that /r/-/l/ contrast is more difficult for Japanese to distinguish than the other contrasts, especially for those whose English proficiency is low.

Table 2: Different rates of identification according to positions – comparison of the perception test in two studies

Result of Mochizuki's Study		Result of Present Study		
Final /l/	98%	Final /r/	85%	Easier
Final /r/	96%	Final /l/	78%	
Initial /r/	90%	Initial /r/	77%	
Initial /l/	86%	Initial consonant-cluster /l/	66%	
Final consonant-cluster /r/	83%	Intervocalic /r/	63%	
Final consonant-cluster /l/	82%	Initial consonant-cluster /r/	62%	
Intervocalic /r/	77%	Initial /l/	59%	
Initial consonant-cluster /l/	73%	Intervocalic /l/	59%	
Intervocalic /l/	69%	Final consonant-cluster /l/	54%	
Initial consonant-cluster /r/	64%	Final consonant-cluster /r/	53%	More difficult

As can be seen in the right column of Table 2, the position of /r/ and /l/ in a word has an effect on the ease of identification of these sounds for the Japanese participants. The data shows a 32% difference according to the position of /r/ and /l/ in a word in the present study. The results of the present study display that final /r/, final /l/, and initial /r/ are easier for Japanese learners of English to perceive as in the case of the results of Mochizuki's study. The initial /l/ was relatively easy for Mochizuki's participants (86%, the fourth easiest sound in the ranking); however, it was relatively difficult for the participants in the present study (59%, seventh in the ranking). Also, final consonant-cluster /r/ and final consonant-cluster /l/ were relatively easy for Mochizuki's participants (83% and 82% respectively), but they were very difficult for the participants in the present study (53% and 54% respectively, the two most difficult sounds). Although the order of difficulty somewhat differs, the bright /l/ exhibits a higher degree of difficulty of identification than dark /l/ in both studies (final /l/-98% and intervocalic /l/-69% in Mochizuki's study, and final /l/-78% and intervocalic /l/-59% in the present study). Some of the participants performed very poorly for the sounds in some positions even though their overall ability to identify /r/ and /l/ was fair. For example, the overall rate of identification for Subject 1 in the present study was 86%. But, she was unable to identify final consonant-cluster /l/. Another participant, Subject 7, could not identify initial /r/ and /l/ although he could identify initial consonant-cluster /r/ and /l/ 100%.

Results of Production Test

Table 3 shows the test scores and percentages for the /r/-/l/ perception test and /r/-/l/ production test. The data shows that the participants who had better perception also had better production. As can be seen in Table 3, Subject 1, 2 and 36 performed better on the perception test than Subject 13, 26, 27, and 33, and they scored higher on the production test as well. These results correspond with my belief that the ability to perceive certain L1-L2 sound differences affects the ability to produce the L2 sound accurately.

Table 3: Individual Japanese subject perception and production accuracy scores

Subject	/r/-/l/ perception	/r/-/l/ production
1	43 (86%)	41 (82%)
2	38 (76%)	39 (78%)
36	41 (82%)	44 (88%)
13	26 (52%)	15 (30%)
26	26 (52%)	28 (56%)
27	26 (52%)	26 (52%)
33	24 (48%)	21 (42%)

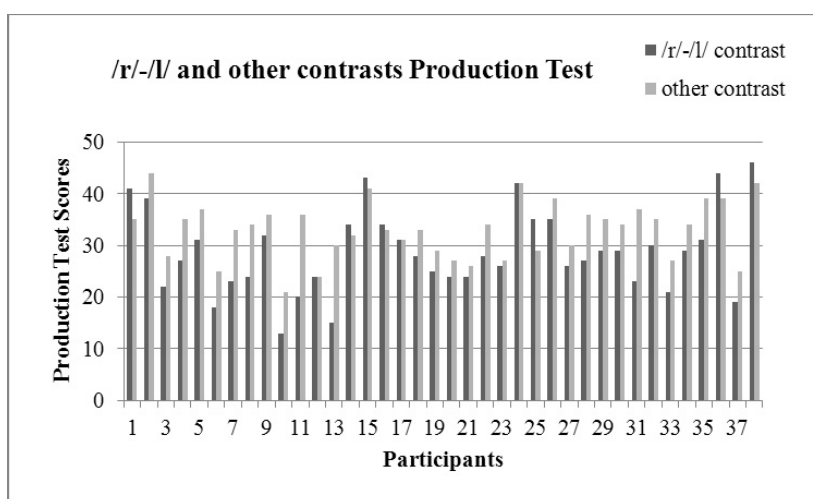


Figure 2: Production performance for /r/-/l/ contrast and the other consonant contrasts

Figure 2 displays production performance on /r/-/l/ and the other consonant contrasts production tests. Most of the participants performed better on the other consonant contrasts production test than /r/-/l/ production test. Although seven participants, Subjects 1, 14, 15, 16, 25, 36, and 38, performed better on /r/-/l/ contrast, the difference in scores between /r/-/l/ and other contrasts is very small. The results suggest that the /r/-/l/ contrast is more difficult to pronounce than the other contrasts.

Similar to the results of the perception test, some aspects of /r/ and /l/ are more difficult to pronounce than those of others. Some of the participants performed very poorly on production of the sounds in some positions even though their overall ability to produce /r/ and /l/ was strong. For instance, the overall rate of production for Subject 15 in this test is 86%. However, he could not pronounce final consonant-cluster /l/ (40%). Subject 2 also performed quite well on the production test (78%), but he could not pronounce final /l/ (0%) and final consonant-cluster /l/ (40%). On the contrary, although Subject 3, 4, 6 were able to pronounce final /l/ 100% and initial consonant-cluster 80%, their overall rates of production were only 44%, 54%, and 36% respectively.

In the perception test, although bright /l/ exhibits a higher degree of difficulty of identification than dark /l/ (19% difference between final /l/-78% and intervocalic /l/-59%), the degree of difficulty in the bright and dark /l/ does not show up in the production test (final /l/-55% and intervocalic /l/-54%). As can be seen in Table 4, the position of /r/ and /l/ in a word affects the

ability to perceive and produce these sounds. While both final /r/ and /l/ are easier to perceive (the two easiest sounds), in respect of production final /r/ is easy (the second easiest sound) but final /l/ is relatively difficult (sixth in the ranking). Similarly, both final consonant-cluster /r/ and /l/ are difficult to perceive (the two most difficult sounds), however, final consonant-cluster /l/ is relatively easy to pronounce. Although percentages of final consonant-cluster /l/ between perception and production do not show much differences (54% and 57% respectively), the degree of difficulty differs among other environments (ninth and fourth in the ranking respectively). Overall, the data does not show a clear pattern of difficulty nor the relationship in difficulty between perception and production.

Table 4: Different rates of identification according to positions – comparison of the perception test and the production test

Result of Perception Test		Result of Production Test		
Final /r/	85%	Initial /l/	77%	Easier
Final /l/	78%	Final /r/	66%	
Initial /r/	77%	Initial consonant-cluster /r/	65%	
Initial consonant-cluster /l/	66%	Final consonant-cluster /l/	57%	
Intervocalic /r/	63%	Intervocalic /l/	55%	
Initial consonant-cluster /r/	62%	Final /l/	54%	
Initial /l/	59%	Initial /r/	52%	
Intervocalic /l/	59%	Initial consonant-cluster /l/	52%	
Final consonant-cluster /l/	54%	Final consonant-cluster /r/	51%	
Final consonant-cluster /r/	53%	Intervocalic /r/	46%	More difficult

Relationship between the perception test and production Test

Table 5: Descriptive statistics of test results

	Central Tendency						Dispersion		
	N	K	M	mode	median	midpoint	low-high	range	S
/r/-/l/ Perception	38	50	32.76	32	32	34	24-43	20	4.50
/r/-/l/ Production	38	50	28.74	24	28	30	13-46	34	7.97

As for /r/-/l/ contrast, most of the participants performed better on the perception than the production test. As can be seen in Table 5, the mean of the perception test is 32.76 and the mean of the production test is 28.74. Specifically, 28 participants performed better on the perception test, and 10 participants performed better on the production test. Subject 3, 6, 10, 11, 13, 19, 21, and 37 performed much better on the perception test with more than a 10 points difference than the production test score. However, there is not enough evidence to generalize that perceiving the foreign sounds is easier than producing the sounds. As for those who performed better on the production test than the perception test, the differences in the test scores between the two tests were not significant except for those of Subject 15 and 38. As to these two participants, their ability to produce the sounds was better than

their ability to perceive them.

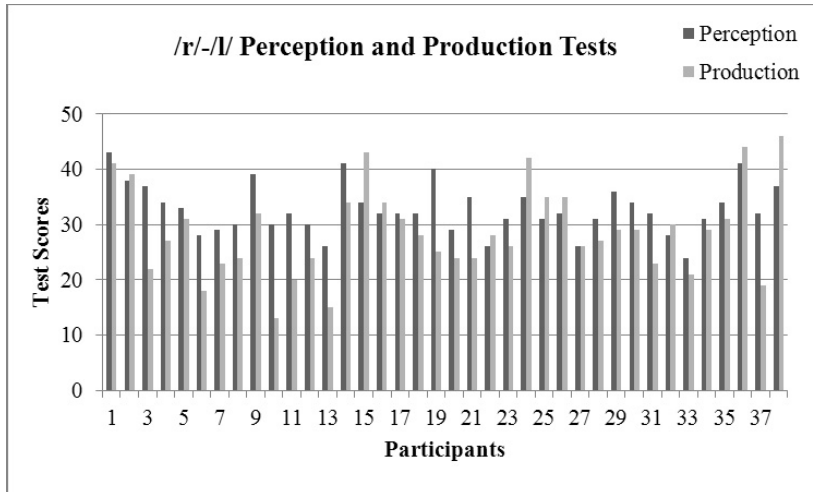


Figure 3: Performance for /r/-l/ contrast perception and production

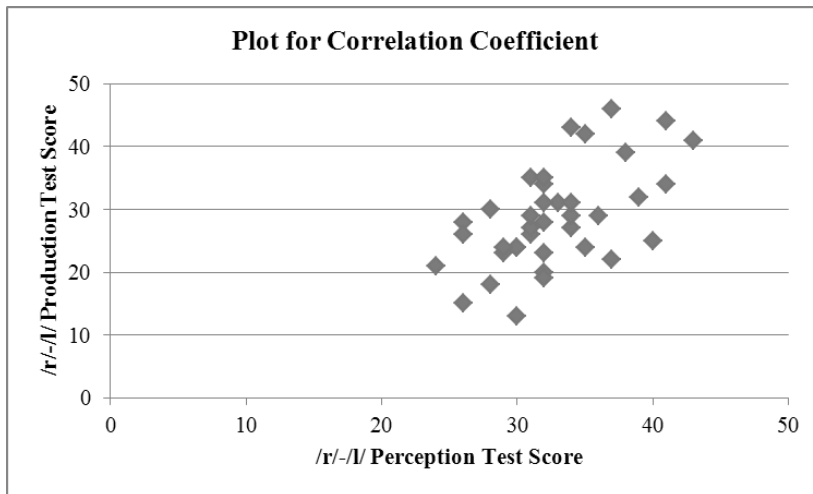


Figure 4: Correlation between the perception test and the production test scores

Figure 4 above is a visual representation of the relationship between the perception test scores and the production test scores. It shows that the correlation is positive although it is not strongly linear. The Pearson product-moment correlation coefficient, or r , is calculated as .579 which is not statistically significant since the magnitude of the correlation $r = .579$ is as large as the critical value, .5760, $p < .05$, two-tailed.

Table 6: Comparison of the perception test and the production test of other consonant contrasts

Perception		Production		
f-v	92%	f-h	80%	Easier
f-h	89%	f-v	74%	
d-ð	80%	b-v	66%	
s-ʃ	74%	d-ð	65%	
s-θ	72%	s-θ	59%	
z-ð	72%	s-ʃ	58%	
b-v	68%	z-ð	51%	More difficult

As for the other consonant contrasts, all participants except three, Subject 15, 22, and 26, performed better on the perception than the production test. As shown in Table 6, the results did not display consistency between the perception and the production. The voiceless alveolar fricative /s/- the voiceless interdental fricative /θ/ contrast was the third most difficult contrast in both perceiving and producing (72% and 59% in accuracy respectively). The voiceless alveolar fricative /s/- the voiceless alveopalatal fricative /ʃ/ contrast was relatively easy to perceive (74% average), however, they were hard for the participants to pronounce (58% average). Similarly, the voiced alveolar fricative /z/- the voiced interdental fricative /ð/ contrast was relatively easy to perceive (72% average), but they were difficult to pronounce (51% average). The differences in the test scores between the two tests of these contrasts were significant (24% and 29%).

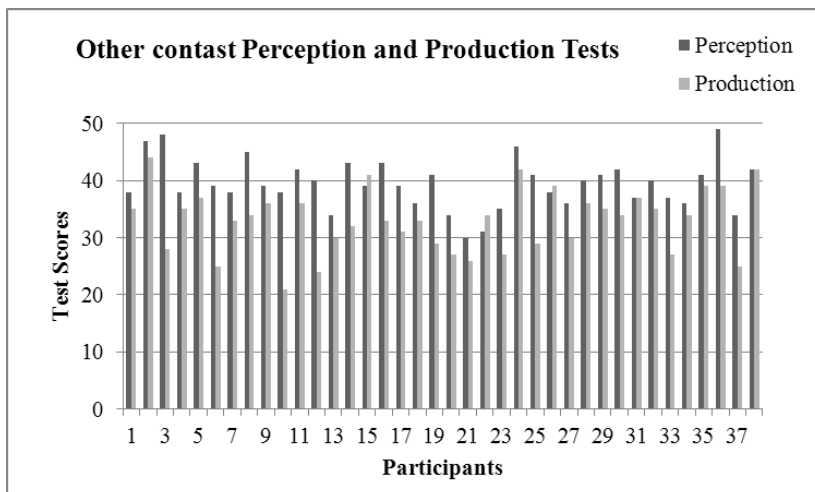


Figure 5: Performance for the other consonant contrasts perception and production

6. Discussion

Summary

The main goal of this study was to explore the relationship between speech perception and production. First, I replicated earlier findings regarding the perceptual difficulty of English for adult Japanese L2 learners. Next, I examined the difficulty with pronunciation of /r/ and /l/ that Japanese L2 learners have. Then, I wished to determine if the ability to perceive sounds is related to the ability to pronounce them. In answer to the first research question, the results of this study confirmed one finding of an earlier study: the position of /r/ and /l/ sounds in a word has a large effect on the ease or difficulty of the perception. In answer to the second research question, the results of the present study also revealed that the position of certain phonemes in a word has a major impact on the ability to pronounce it. According to the results presented, it is clear that Japanese natives exposed to English in adulthood have great difficulty identifying or discriminating between /r/-/l/ contrast even after years of exposure to English. Japanese exhibit different abilities in terms of identifying and pronouncing /r/ and /l/, /s/ and /θ/, /ð/ and /z/, and other phonemes according to their positions in a word. The results do not evidence any noticeable relationship between the perception ability and the production ability. Two participants showed strong production ability and poor perception ability. Thus, the results do not support the idea that the ability to perceive non-native sounds leads to better production ability to pronounce the sounds.

Limitations

The use of only one judge in the evaluation on L2 production was one of the drawbacks in this study. An English native-speaker participant rated all 38 participants' 50 /r/-/l/ contrast utterances and utterances of 50 words with other contrasts. If there were multiple judges, the results of the evaluation on the production test might be different and more reliable.

Another limitation of this study is the production test procedure. Some of the participants did not know how to pronounce several words. For example, many participants did not know how to pronounce "breathe" and pronounced it [breθ] instead of [brið], and the rater circled "neither of them" on the answer sheet in the given "breathe-breed" minimal pair. Such mispronunciation leads to lower scores. Therefore, the model pronunciation should be given in addition to the word list to ensure more accurate results. In addition, not having a large number of minimal pair words can be another reason for the unexpected results.

In regards to the Japanese participants' production, because the list of English words was provided, the participants' articulation might have been influenced by the visual stimuli. If the definition or translation of English words were given in Japanese, and if they had to pronounce the words based on their knowledge, the result might be different. It would be more appropriate for examining the relationship between the perception ability and the production ability. As for me, the spelling raises my awareness of articulation. Thus, the production test procedure should have been designed more carefully.

7. Conclusion

As was previously noted, some studies on perception and perceptual training have been conducted on Japanese adult learners of English. Along with such studies, numerous studies have suggested that many L2 production difficulties are rooted in perception. Moreover, one piece of research exemplified that the production ability can be automatically improved by improving perception ability. If the production ability can be improved by perception training without direct production training, as the study shows, then the production ability must be improved greatly when explicit production training is provided. Prator and Robinett (1985) claimed that success in pronunciation depends largely on the sharpness of the ear. Yule et al. (1987) also asserted that the crucial component in developing effective L2 pronunciation is the development of listening skills. As stated, although the strong correlation between the perception ability and the production ability was not observed in this study, these two abilities are deeply related to each other.

For possible future research in this area, I would like to investigate how much adult Japanese learners of English can improve their production if training is given and what kind of training is effective. As the research on L2 production has been carried out under strict laboratory conditions, it may be perceived as unpractical. Thus, it may not be clear how the findings apply to the classroom and how to integrate appropriate pronunciation instruction into second/foreign language classrooms (Derwing and

Munro, 2005). Furthermore, Jenkins (2000, 2002) argued that English learners should not have to adapt to native speaker norms. In her study of teachers' attitudes (2005), she supported ELF pronunciation and claimed that it will enhance rather than damage English learners' future social and economic prospects. However, I believe that articulation is very important and should be taught in school.

In conclusion, this study was exploratory in nature; future studies require many refinements in the choice and construction of measurement instruments.

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APPENDIX A

Perception Test Answer Sheet on /r/-l/ adapted from Mochizuki (1981)

1. right	light	26. arrive	alive
2. read	lead	27. storing	stalling
3. red	led	28. arrive	alive
4. room	loom	29. farrow	fallow
5. right	light	30. berry	belly
6. rock	lock	31. fort	fault
7. red	led	32. sort	salt
8. room	loom	33. cord	called
9. rock	lock	34. Mort	malt
10. read	lead	35. sort	salt
11. cramp	clamp	36. fort	fault
12. pray	play	37. force	false
13. fruit	flute	38. Mort	malt
14. fresh	flesh	39. force	false
15. cramp	clamp	40. cord	called
16. pray	play	41. poor	pool
17. brush	blush	42. tower	towel
18. brush	blush	43. core	call
19. fruit	flute	44. peer	peal
20. fresh	flesh	45. shore	shawl
21. berry	belly	46. peer	peal
22. storing	stalling	47. shore	shawl
23. tarry	tally	48. tower	towel
24. farrow	fallow	49. poor	pool
25. tarry	tally	50. core	call

Perception Test Answer Sheet on other contrast

1. thick	sick	26. curb	curve
2. mouth	mouse	27. best	vest
3. path	pass	28. bat	vat
4. think	sink	29. bat	vat
5. think	sink	30. curb	curve
6. thick	sick	31. best	vest
7. mouth	mouse	32. boat	vote
8. path	pass	33. they	day
9. fan	van	34. then	den
10. ferry	very	35. breathe	bread
11. safe	save	36. those	doze
12. leaf	leave	37. then	den

13. fan	van	38. those	doze
15. ferry	very	39. breathe	breed
15. leaf	leave	40. they	day
16. safe	save	41. sea	she
17. few	hue	42. seat	sheet
18. fear	hear	43. sip	ship
19. funny	honey	44. breathe	breeze
20. force	horse	45. rhythm	risen
21. force	horse	46. rhythm	risen
22. funny	honey	47. breathe	breeze
23. few	hue	48. sip	ship
24. fear	hear	49. sea	she
25. boat	vote	50. seat	sheet

Production Test adapted from Mochizuki (1981)

1. rock	26. tarry
2. room	27. follow
3. led	28. alive
4. read (present tense)	29. berry
5. light	30. storing
6. right	31. salt
7. lock	32. cord
8. lead (verb)	33. fort
9. loom	34. force
10. red	35. Mort
11. cramp	36. called
12. play	37. fault
13. blush	38. sort
14. pray	39. false
15. flesh	40. malt
16. fruit	41. call
17. clamp	42. peer
18. brush	43. pool
19. flute	44. shawl
20. fresh	45. tower
21. tally	46. peal
22. stalling	47. core
23. arrive	48. shore
24. farrow	49. poor
25. belly	50. towel

Production Test on other contrast

1. thick	26. curb
2. mouth	27. vest
3. path	28. vat
4. sink	29. bat
5. think	30. curve
6. sick	31. best
7. mouse	32. boat
8. pass	33. they
9. fan	34. den
10. very	35. breathe
11. safe	36. doze
12. leaf	37. then
13. van	38. those
14. ferry	39. breed
15. leave	40. day
16. save	41. sea
17. few	42. sheet
18. hear	43. ship
19. honey	44. breeze
20. force	45. rhythm
21. horse	46. risen
22. funny	47. breathe
23. hue	48. sip
24. fear	49. she
25. vote	50. seat

APPENDIX B

Test scores

Subjects	/r/-l/ perception	/r/-l/ production	Other perception	Other production
1	43 (86%)	41 (82%)	38 (76%)	35 (70%)
2	38 (76%)	39 (78%)	47 (94%)	44 (88%)
3	37 (74%)	22 (44%)	48 (96%)	28 (56%)
4	34 (68%)	27 (54%)	38 (76%)	35 (70%)
5	33 (66%)	31 (62%)	43 (86%)	37 (74%)
6	28 (56%)	18 (36%)	39 (78%)	25 (50%)
7	29 (58%)	23 (46%)	38 (76%)	33 (66%)
8	30 (60%)	24 (48%)	45 (90%)	34 (68%)
9	39 (78%)	32 (64%)	39 (78%)	36 (72%)
10	30 (60%)	13 (26%)	38 (76%)	21 (42%)
11	32 (64%)	20 (40%)	42 (84%)	36 (72%)
12	30 (60%)	24 (48%)	40 (80%)	24 (48%)
13	26 (52%)	15 (30%)	34 (68%)	30 (60%)
14	41 (82%)	34 (68%)	43 (86%)	32 (64%)
15	34 (68%)	43 (86%)	39 (78%)	41 (82%)
16	32 (64%)	34 (68%)	43 (86%)	33 (66%)
17	32 (64%)	31 (62%)	39 (78%)	31 (62%)
18	32 (64%)	28 (56%)	36 (72%)	33 (66%)
19	40 (80%)	25 (50%)	41 (82%)	29 (58%)
20	29 (58%)	24 (48%)	34 (68%)	27 (54%)
21	35 (70%)	24 (48%)	30 (60%)	26 (52%)
22	26 (52%)	28 (56%)	31 (62%)	34 (68%)
23	31 (62%)	26 (52%)	35 (70%)	27 (54%)
24	35 (70%)	42 (84%)	46 (92%)	42 (84%)
25	31 (62%)	35 (70%)	41 (82%)	29 (58%)
26	32 (64%)	35 (70%)	38 (76%)	39 (78%)
27	26 (52%)	26 (52%)	36 (72%)	30 (60%)
28	31 (62%)	27 (54%)	40 (80%)	36 (72%)
29	36 (72%)	29 (58%)	41 (82%)	35 (70%)
30	34 (68%)	29 (58%)	42 (84%)	34 (68%)
31	32 (64%)	23 (46%)	37 (74%)	37 (74%)
32	28 (56%)	30 (60%)	40 (80%)	35 (70%)
33	24 (48%)	21 (42%)	37 (74%)	27 (54%)
34	31 (62%)	29 (58%)	36 (72%)	34 (68%)
35	34 (68%)	31 (62%)	41 (82%)	39 (78%)
36	41 (82%)	44 (88%)	49 (98%)	39 (78%)
37	32 (64%)	19 (38%)	34 (68%)	25 (50%)

38	37 (74%)	46 (92%)	42 (84%)	42 (84%)
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Test Scores: /r/-/l/ contrast

Perception

Subject	Ini. /r/	Ini. /l/	I.C.-C.		InerV.		InterV.		F.C.-C.		Fin. /r/	Fin. /l/	Total
			/r/	/l/	/r/	/l/	/r/	/l/	/r/	/l/			
1	5	5	4	5	4	4	2	4	5	5	43		
2	5	4	4	4	2	4	3	3	5	4	38		
3	3	3	3	3	4	4	3	4	5	5	37		
4	5	2	5	4	2	4	1	3	4	4	34		
5	3	2	2	3	3	3	3	4	5	5	33		
6	3	3	3	2	3	3	1	1	5	4	28		
7	1	1	5	5	3	2	2	2	3	5	29		
8	5	3	2	3	4	3	2	1	4	3	30		
9	3	3	4	4	3	3	5	5	4	5	39		
10	4	3	2	2	3	4	2	1	4	5	30		
11	4	3	2	2	2	2	4	5	4	4	32		
12	4	3	3	4	1	1	3	4	4	3	30		
13	3	0	3	3	5	2	1	3	4	2	26		
14	4	4	4	4	3	3	5	4	5	5	41		
15	4	4	4	3	3	3	3	2	4	4	34		
16	4	3	1	5	2	3	2	4	5	3	32		
17	3	3	3	3	4	3	4	3	3	3	32		
18	3	3	4	2	3	3	2	2	5	5	32		
19	5	3	3	3	5	5	3	3	5	5	40		
20	4	3	2	4	1	2	1	3	5	4	29		
21	5	5	3	3	3	3	2	3	4	4	35		
22	4	2	1	2	2	1	3	3	4	4	26		
23	3	2	2	3	4	3	4	4	3	3	31		
24	5	4	2	3	3	4	3	3	5	3	35		
25	5	4	5	4	1	3	2	0	5	2	31		
26	3	3	3	1	4	3	4	2	4	5	32		
27	3	3	3	3	2	2	2	1	4	3	26		
28	3	2	4	4	3	3	1	1	5	5	31		
29	5	4	4	4	2	3	4	3	4	3	36		
30	5	3	3	4	4	3	2	3	4	3	34		
31	3	3	2	2	4	3	4	4	4	3	32		
32	4	4	2	2	4	3	1	0	5	3	28		

Between Perception and Production: Is the ability to hear L1-L2 sound differences related to the ability to pronounce the same sounds accurately?

33	3	0	3	2	3	3	3	0	4	3	24
34	3	2	2	3	4	3	2	2	5	5	31
35	4	3	5	5	3	2	4	3	2	3	34
36	5	5	3	4	5	5	3	3	3	5	41
37	4	4	3	3	3	3	1	3	4	4	32
38	4	2	4	5	5	1	3	3	5	5	37

Production

Subject	Ini. /r/	Ini. /l/	I.C-C.		InerV.		F.C-C.		Fin. /r/	Fin. /l/	Total
			/r/	/l/	/r/	/l/	/r/	/l/			
1	5	5	5	4	2	4	3	5	3	5	41
2	5	5	4	5	4	4	5	2	5	0	39
3	0	5	4	1	2	2	1	1	3	3	22
4	0	5	3	1	2	2	2	4	4	4	27
5	1	5	5	1	4	1	5	0	5	4	31
6	0	5	4	1	0	1	3	3	1	0	18
7	1	5	5	0	0	2	3	2	4	1	23
8	1	5	1	3	1	3	1	5	3	1	24
9	4	3	4	1	1	3	5	2	5	4	32
10	1	1	4	0	1	3	2	0	1	0	13
11	0	3	3	1	1	2	3	1	5	1	20
12	1	4	5	0	1	2	1	4	5	1	24
13	0	3	1	1	1	3	0	2	3	1	15
14	4	5	4	4	2	4	2	3	2	4	34
15	5	4	5	4	4	5	2	5	5	4	43
16	4	5	4	5	3	2	3	2	4	2	34
17	4	4	3	3	4	2	1	3	3	4	31
18	2	3	3	2	2	3	3	4	2	4	28
19	3	4	3	2	1	3	2	2	2	3	25
20	2	3	1	3	2	3	4	2	2	2	24
21	2	3	2	3	1	3	3	3	2	2	24
22	3	3	3	3	3	2	4	3	3	1	28
23	2	3	2	5	2	2	2	4	1	3	26
24	5	5	4	3	5	5	3	4	3	5	42
25	2	4	3	4	4	4	2	4	4	4	35
26	4	5	2	4	3	2	4	2	5	4	35
27	3	3	2	3	3	2	1	3	4	2	26
28	3	3	3	2	4	2	2	2	3	3	27

29	3	4	3	4	2	4	0	3	3	3	29
30	4	3	3	3	1	3	2	4	4	2	29
31	2	3	2	2	0	2	3	3	4	2	23
32	2	4	3	2	3	3	3	3	4	3	30
33	2	3	3	3	2	3	1	2	1	1	21
34	2	3	4	2	2	3	2	4	4	3	29
35	5	4	3	3	3	2	2	2	3	4	31
36	5	5	4	3	5	4	5	5	4	4	44
37	2	2	1	3	1	1	2	2	2	3	19
38	5	5	5	5	5	4	4	3	5	5	46

Test Scores: other consonant contrasts

perception									production								
Subject	f-v	f-h	d-th	s-th	s-sh	b-v	th-z	Total	Subject	f-v	f-h	d-th	s-th	s-sh	b-v	th-z	Total
1	7	6	6	6	3	6	4	38	1	5	7	8	3	3	7	2	35
2	8	8	6	8	6	7	4	47	2	7	8	6	7	6	7	3	44
3	8	7	8	8	6	7	4	48	3	5	5	5	5	3	3	2	28
4	8	8	2	7	3	6	4	38	4	8	6	3	7	3	7	1	35
5	8	8	7	7	4	6	3	43	5	7	7	7	5	3	5	3	37
6	8	8	6	6	5	6	0	39	6	6	7	3	2	4	3	0	25
7	8	7	6	5	5	4	3	38	7	6	5	5	5	4	5	3	33
8	8	8	8	8	3	6	4	45	8	7	7	6	3	3	6	2	34
9	8	6	7	8	4	5	1	39	9	6	7	5	5	3	7	3	36
10	8	6	7	5	2	7	3	38	10	4	3	2	4	3	3	2	21
11	8	8	8	4	4	7	3	42	11	5	8	6	5	4	7	1	36
12	7	7	5	5	6	6	4	40	12	5	6	5	1	3	3	1	24
13	7	7	6	3	3	5	3	34	13	4	8	6	4	3	3	2	30
14	6	7	8	6	6	6	4	43	14	5	7	5	4	4	6	1	32
15	8	8	3	8	4	6	2	39	15	8	8	5	5	5	7	3	41
16	8	8	7	8	4	5	3	43	16	7	7	7	4	2	5	1	33
17	6	8	6	8	4	6	1	39	17	8	6	5	5	3	2	2	31
18	7	8	8	2	4	6	1	36	18	5	7	7	3	3	5	3	33
19	7	6	7	8	4	5	4	41	19	4	5	4	6	4	5	1	29
20	8	6	4	5	5	4	2	34	20	6	6	4	4	3	3	1	27
21	7	7	3	2	4	5	2	30	21	6	5	3	3	4	4	1	26
22	6	8	5	6	3	2	1	31	22	5	4	5	7	4	7	2	34
23	7	6	8	3	2	6	3	35	23	3	5	4	4	2	7	2	27
24	8	8	7	7	4	8	4	46	24	6	7	7	6	5	7	4	42
25	7	8	7	6	6	4	3	41	25	5	5	5	5	3	5	1	29
26	7	7	5	7	6	4	2	38	26	7	6	6	8	3	7	2	39

Between Perception and Production: Is the ability to hear L1-L2 sound differences related to the ability to pronounce the same sounds accurately?

27	8	7	7	3	6	2	3	36	27	5	6	6	4	3	3	2	29
28	7	8	8	4	3	6	4	40	28	6	7	6	4	3	7	3	36
29	7	8	8	6	6	3	3	41	29	6	6	7	4	4	6	2	35
30	8	8	7	8	5	2	4	42	30	6	7	6	6	3	4	2	34
31	8	7	4	7	4	4	3	37	31	8	8	7	5	1	7	1	37
32	8	4	6	7	5	6	4	40	32	8	5	5	4	4	6	3	35
33	6	6	7	2	6	6	4	37	33	5	6	3	4	4	2	3	27
34	8	6	7	4	2	6	3	36	34	5	5	5	4	6	7	1	33
35	8	8	7	6	4	8	0	41	35		8	5	6	3	7	2	39
36	8	7	8	8	6	8	4	49	36	7	8	7	8	2	4	3	39
37	5	6	5	3	5	7	3	34	37	4	7	1	3	3	4	3	25
38	7	7	8	6	6	5	3	42	38	8	7	6	8	6	7	4	46