

An Analytic Study of English and Japanese Consonantal Sounds

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「日本語と英語の子音音声の分析研究」

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I. Introduction

There is a wide variety of consonants in the languages of the world. When the two languages, English and Japanese are compared there are some consonant phonemes which do not appear in common in the two languages. Thus, for example, English has interdental consonant /θ/ and /ð/, and labiodental consonant /f/ and /v/, but in Japanese, we will find no consonants which have the same places of articulation as such English consonants. Otherwise, Japanese has a voiceless bilabial fricative consonant /ɸ/ and a voiceless palatal fricative consonant /ç/, but in English, we can't find the consonants which have the same manners of articulation at the same places of articulation as such Japanese consonants. Furthermore, we can find some consonants which have the same places of articulation, but have different manners of articulation when we compare the consonants of two languages. For example, English has a voiced alveolar lateral consonant /l/ and a voiced alveolar glide consonant /r/, but Japanese has only one alveolar flap (or tap) consonant /ɾ/ which is equivalent to those two English consonants. In Japanese, consonants /t/, /d/, /s/, /z/, /ts/ and /dz/ are dental consonants, but those consonants except for the last two sounds /ts/ and /dz/, which are not found in English, are alveolar consonants in English. The above contrast between the two languages is the contrast of the consonants themselves; however, we also have to compare two languages from another point of view.

Japanese consonants have a special characteristic which doesn't appear in English. In Japanese, except in a very few cases (such as syllabic [ŋ]), the consonants are always followed by vowels and those two elements constitute a syllable which is symbolized as the characteristic of Japanese consonants. This sequence which consists of a vowel and a consonant is called "onsetsu" in Japanese, and "mora" in English. There are three types of sequences which may constitute a mora in Japanese, that is, one consonant followed by a vowel, a vowel itself, and a consonant [ŋ] not followed by a vowel.

Thus Japanese consonant clusters are much more limited in distribution than English ones, and ordinary Japanese never think of the Japanese consonants in isolation or in free clusters like English consonants. The following examples show such specific consonantal sound distribution of Japanese.

* General Education

Japanese Consonantal Sound — Key Words

- [p] — ippen (a piece), onpu (musical note)
 [b] — baka (foolish), taba (bunch)
 [t] — uta (song), oto (sound)
 [d] — dai (stand), denwa (telephone)
 [k] — kami (hair), teki (enemy)
 [g] — gaka (painter), geki (play)
 [ʔ] — ita (said), shita (knew)
 [Φ] — Fujisan (Mt. Fuji), toufu (soy-bean curd)
 [s] — sumi (corner), yasui (cheap)
 [z] — nazo (riddle), zeni (money)
 [ʃ] — shita (under), ushi (cow)
 [ʒ] — gisa (difference of time), saji (spoon)
 [ç] — ehon (picture book), zehi (good or not)
 [h] — haru (attack), hake (brush)
 [ts] — tsuki (moon), itsu (when)
 [dz] — zurui (crafty), mizu (water)
 [tʃ] — chi (blood), machi (town)
 [dʒ] — jyoshi (woman), ijyoo (that's all)
 [m] — miru (look), komu (crowd)
 [n] — niru (boil), kinu (silk)
 [ŋ] }
 [n] } — sangai (the third floor), sen (thousand)
 [ɹ] — raku (comfort), kiru (cut)
 [w] — waki (side), suwaru (sit)
 [j] — yama (mountain), ie (house)

II. Analytic study of English and Japanese consonants considering their sound distribution in accordance with the manner of articulation

(1) English consonants

(a) Stop

Voiceless stop consonants /p/, /t/, and /k/, are aspirated when they occur word initially, but voiced stop consonants /b/, /d/, and /g/, are not aspirated in the same condition. Such voiced stop consonants are partly voiced in word initial and word final position. Also these stop consonants affect the duration of vowels. The vowels are much shorter before the voiceless consonants /p, t, k/ than before the voiced consonants /b, d, g/. Table 1 shows the results of actual measurements of such vowels (Higgs and Hodson, 1978). On the contrary, such voiceless consonants /p, t, k/ have longer duration time than the voiced consonants /b, d, g/.

Also there are some general phonological rules about stop consonants. First, word final stops are usually unexploded when the next words begin with nasal or stop sounds. Second, glottal stop /ʔ/ frequently occurs as an allophone of /t/, but in American English, /t/ becomes an alveolar tap /ɾ/ after a stressed vowel and before an unstressed syllable other than syllabic nasal [ŋ].

(b) Fricative and Affricate

There are some phonological rules that can apply to fricative and affricate sounds. First, vowels before

| Vowel durations before word-final obstruent cognates (ms)* | | | | | | | |
|--|-----|-----|------|-------|-----|-----|------|
| | | | | Ratio | | | |
| rope | (a) | 136 | robe | (a) | 204 | (a) | 0.67 |
| | (b) | 132 | | (b) | 261 | (b) | 0.51 |
| seat | (a) | 104 | seed | (a) | 173 | (a) | 0.60 |
| | (b) | 144 | | (b) | 260 | (b) | 0.55 |
| pick | (a) | 72 | pig | (a) | 112 | (a) | 0.64 |
| | (b) | 126 | | (b) | 224 | (b) | 0.61 |
| ice | (a) | 195 | eyes | (a) | 421 | (a) | 0.46 |
| | (b) | 293 | | (b) | 448 | (b) | 0.65 |

*(a) utterances in normal speaking voice. (b) utterances in whisper.

Table 1 (Higgs and Hodson, 1978)

voiceless fricative or affricate sounds are shorter than before voiced fricative or affricate sounds as well as stops. Second, final voiceless fricative or affricate sounds are longer than the voiced ones. Third, the final voiced fricative or affricate sounds are not fully voiced sounds unless the next sound is also voiced.

(c) Nasal

Nasal sound /m/ and /n/ can be syllabic as well as /r/ and /l/ when they occur at the ends of words. Another nasal sound /ŋ/ can not occur word-initially; it can occur only within or at the ends of words.

(d) Approximants

The approximants /r, w, l/ are largely voiceless when they follow one of the voiceless stops /p, t, k/. The approximant /j/ usually occurs with the restriction that the following vowel is /u/. The approximant /h/ can occur only before vowels, or before another approximant, /j/ or /w/.

(2) Japanese Consonants

(a) Stop

Voiceless stop consonants /p, t, k/ are relatively longer than corresponding voiced ones in the same environment. For example, if we pronounce such minimal pairs as /watajino pan/ (my bread) and /watajino ban/ (my turn) with the same intonational pattern and speed, a voiceless sound /p/ is found to be constantly longer than a voiced sound /b/. Similarly, a pair of voiced and voiceless consonants can be compared in another example such as /itai/ (wish to stay) and /idai/ (great). It is fairly difficult to know this fact from our perception, but the spectrograms show us the evidence clearly. One good example can be seen in the research conducted by Mieko Shimizu Han in 1962.

In the research, about 50 spectrograms were made from three speakers. As the result, the voiceless sounds /p, t, k/ show approximately 20 to 40% increase in duration over their corresponding voiced ones /b, d, g/. Furthermore, it was observed that there are minor differences in duration among different stop consonants. For example, if we compare the three voiceless stops /p, t, k/, /p/ has longer duration than /t/ or /k/. In the case of long or geminate stops /pp, tt, kk/, the minor differences in duration due to the place of articulation is clearly observed. As the results of spectrographic analysis by Han, bilabial stop /pp/ is usually 10% longer in duration

than velar stop /kk/.

In Japanese, such geminate stops /pp, tt, kk/ are often pronounced as the ejective sounds [p', t', k']. Thus, for example, the word /suppai/ (sour) is pronounced [sup'ai], same as /itta/ (went) is pronounced [it'a]. This fact will be found in a result that the duration of short and long consonants is, on average, in the ratio of 1.0 to 3.0 according to Han. In another way, the long consonants which are usually symbolized as double consonants are actually much longer than the short consonants. Han's research also reveals a fact that the closure of /k/ in /hakada/ (it's a tomb) last 11.5 centiseconds while the closure of /kk/ in /hakkada/ (it's mint) last 31.5 centiseconds, as well as the closure of /t/ is 8.5 centisecond while /tt/ is 25.0 centiseconds.

Voiceless stop consonants /p, t, k/ and voiced stop consonants /b, d, g/ show us different characteristic under the condition of VCV or CVC utterances. According to the research done by Tabata and Sakai in 1974, voiceless stops /p, t, k/ have less variation in a syllable than voiced stop /b, d, g/.

Concerning topic, a research which was done by Hirose and Ushijima in 1978 gives us acoustical information about voiceless stop /p, t, k/. According to the research, word-medial voiceless consonants have about two times the glottal width and more than two times the posterior cricoarytenoid activity than word-initial voiceless consonants.

(b) Fricative and Affricate

The voiceless fricative and affricate consonants /s, ʃ, tʃ, ts/ have longer duration than the voiced ones, as well as stop sounds. Also fricative and affricate sounds have much longer duration than twice of the short counterparts when these sounds are symbolized as double consonant. For example, /ʃ/ in /iʃo/ (will) and /ʃʃ/ in /iʃʃo/ (together). But in this case, phonological process for the change is a little different from that of the stops. In this case, the consonant is lengthened by neighboring syllables, so the duration of /ʃ/ and /ʃo/ are pronounced as almost same length. This was confirmed by spectrographic analysis by Han (Mieko Shimizu Han, 1962).

Furthermore, a research shows that fricative sounds have wider glottal opening and much more PCA activity than stop sounds. (Hirose and Ushijima, 1978)

(c) Nasal

In Japanese, a nasal sound /ŋ/ is an allophone of /g/, and this sound never occurs at the word initial.

A nasal sound [ŋ] is the only consonant that is syllabic.

Nasal sounds can appear as the double consonants which have long duration. For example, /m/ of /jimai/ (sisters) lasts 9.0 centiseconds while /mm/ of /jimmai/ (untrained) lasts 23.0 centiseconds according to Han (1962).

(d) Flap (or tap)

An alveolar flap sound can not become syllabic, so this sound is always followed by vowels.

(e) Approximant

All sounds are much similar to English sounds, except the lacking of a sound /r/.

As a conclusion of this study, the main phonological rules and characteristic of English and Japanese consonantal sounds can be summarized as in following:

(1) English

There are 25 consonants.

- i) /p/, /t/, and /k/ are aspirated at initial position of a word, but /b/, /d/, and /g/ are not.
- ii) vowels — short before voiceless consonants.
- iii) vowels — long before voiced consonants.
- iv) voiceless consonants — short duration.
- v) voiced consonants — long duration.

- vi) stops are not exploded before stops or nasals.
- vii) glottal stops [ʔ] is an allophone of /t/.
- viii) [m], [n], [ɾ], and [l] are syllabic.
- ix) /r, w, l/ are voiceless before /p, t, k/.

(2) Japanese

There are 24 consonants.

- i) voiceless consonants have longer duration than voiced ones.
- ii) stop, fricative, nasal have lengthened consonants.
- iii) /p, t, k/ have less variation than /b, d, g/.
- iv) word-medial /p, t, k/ — wider glottis and more active PCA.
- v) [n] is a syllabic.

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要 約

日本語と英語の子音について、まず、音素の数の面から比較してみると、前者が24個あるのに対して後者は25個であり、ほぼ同数である。

しかしながら、個々の音韻及び音韻体系の面から考えると、両者の間にはかなりの違いが存在する。例えば、日本語には無声の両唇摩擦音や硬口蓋音が存在するが、英語にはそのような音韻は存在しない。一方、英語には日本語には存在しない唇歯音や歯間音を含んでいる。また、英語の歯茎音の多くは、日本語では歯音として発音される。

本研究では、日本語と英語に存在するこのような基本的な違いを踏まえたうえで、両者を特徴づけている独特の音韻配列や音韻法則の違いに焦点をあて、スペクトログラフによる測定結果にも言及しながら、分析研究することを試みた。