SHORT NOTE

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Mouth shape of the [Φ] and [w] sounds pronounced in loan words in Japanese

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Labial Sounds in the Traditional Japanese Syllables

Among the visual information concerning the mouth shape for lipreading of Japanese,[1] the most useful clue is the articulation of the lips.

The consonants [p], [b] and [m] preceded or followed by any of the five Japanese vowels are definitely readable even in continuous speech because of their closure of the lips.

On the other hand, the rules related to [w], which is found often in the important Japanese words such as /'wa/ (particle) and /'watakusi/ or /'watasi/ (that means "I"), are rather complicated because a similar mouth shape can also be seen in [u] and /h/ in the traditional Japanese syllable /hu/ (pronounced as unvoiced bilabial fricative [Φ]). In addition to this, the sounds [w] and [Φ] are pronounced not only in the syllables /'wa/ and /hu/ but also in syllables followed by other vowels, especially for loan words in modern Japanese.

[Φ] and [w] Sounds in the Loan Words

The official rules of Japanese orthography recommend the transcription of the sounds [fa], [fi], [fe] and [fo] in the original words as /ha/, /hi/, /he/ and /ho/, and [wi], [we] and [wo] as two syllables /'u'i/, /'u'e/ and /'u'o/.

These transcriptions, of course, have influenced the pronounciation of loan words, and some of these which have been used for a long time are pronounced, especially by old people, in the way that they are described. (Examples: [huan] for "fan" and [sutoppuuottʃi] for "stopwatch.")

Nowadays, however, many young people and children use in their natural utterance the sounds [Φ], which is between [f] in the original words and [h] or [ç] in the traditional Japanese syllables, for [fa], [fi], [fe] and [fo], and, monosyllabic sounds which are close to the original, for [wi], [we] and [wo].

Table 1 Classification of syllables including labial sounds.

Traditional	/a/	/i/	/u/	/e/	/o/	/ja/	/ju/	/jo/
/h/	[ha]	[çi]	[ɸu]	[he]	[ho]	[ça]	[çu]	[ço]
/'/	[a]	[i]	[u]	[e]	[o]	[ja]	[ju]	[jo]
/'w/	[wa]							

Rearranged	[a]	[i]	[u]	[e]	[o]
[h]	[ha]			[he]	[ho]
[ç]	[ça]	[çi]	[çu]	[çe]	[ço]
[ɸ]	[ɸa]	[ɸi]	[ɸu]	[ɸe]	[ɸo]
	[a]			[e]	[o]
[j]	[ja]	[i]	[ju]	[je]	[jo]
[w]	[wa]	[wi]	[u]	[we]	[wo]

Classification of Syllables Including Labial Sounds

The traditional Japanese syllables have been classified, based on a matrix composed of the five Japanese vowels and semivowel [j]+vowel [a], [u] and [o] as rows, and various consonants as columns. In this matrix, the syllable /hu/ has been included in a row having phoneme /h/ common, although only the syllable /hu/ is pronounced as bilabial. The syllable /'wa/ has been situated in a special row consisting only of itself (Table 1).

These unvoiced fricatives in the /h/ row, however, can be rearranged by classifying them based on the place of articulation into the three rows; namely, laryngeal fricatives [h] in /ha/, /he/ and /ho/, palatalized fricatives [ç] in /hi/, /hja/, /hju/ and /hjo/, and the bilabial fricative [Φ] in /hu/.

The syllables in the /'/ rows, that is the syllables consisting of only vowel, or semivowel+vowel, and the syllable /'wa/ can be rearranged in the same way as the unvoiced fricatives. Thus, both the traditional Japanese syllables and the syllables with [Φ] and [w] which are found in the loan words in the modern Japanese can be classified systematically.

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Table 2 Number of loan words which involve [Φ] and [w] sounds.

	Φa	Φi	Φu	Φe	Φo
INITIAL	36	25	44	21	29
INTERVOCALIC	24	26	89	21	18
TOTAL	60	51	133	42	47
	wa	wi	u	we	wo
INITIAL	29	19	13	14	14
INTERVOCALIC	23	8	47	16	9
TOTAL	52	27	60	30	23

Number of Loan Words Which Involve [Φ] and [w] Sounds

The statistics concerning the loan words which involve either [Φ] or [w] sounds were obtained from a standard Japanese Dictionary,[2] a list of the most frequent words,[3] and by extracting some others found often in daily speech.

The result shows that the number of loan words, which involve each of the syllables in the [Φ] row is more than forty, and they include such words that are popular even among children (Table 2). (Examples: "Sapphire," "Film," "Football," "Buffet" and "Symphony.")

The number of loan words which involve each of the syllables in the [w] row is less than those involving the [Φ] sound; still it is more than twenty, and they include many frequently used words. (Examples: "Waltz," "Darwin," "Cowboy," "Western," and "Vodka.")

Mouth Shapes of [Φ] and [w] Sounds

The mouth of a speaker was illuminated by a stroboscopic light source every 10 ms (or 20 ms), and pictures of both the frontal and lateral views of the mouth were taken utilizing a special camera in which a long strip of film was driven continuously. Change in the dimensions of various parts of the mouth were measured in these pictures.

The speaker was a female adult, one of the present authors.

The stroboscopic pictures of the mouth shape of [Φ] and [w] sounds in the utterance of the syllables in the [Φ] and [w] rows shows that the lips are narrowed and rounded more than in the syllable [u]. It is also shown that the protrusion of the lips in the utterances of unvoiced fricative [Φ] is slightly larger than that of [w] (Fig. 1).

Acoustical Properties of [Φ] and [w] Sounds

Soundspectrograms of the syllables in the [Φ] row shows that the [Φ] portion is filled by the noise components of the fricative sound. Some of them have a clear transition from a spectral peak of the noise (at about the second formant frequency of vowel [u]) to the second formant of the following vowel (Fig. 2).

The utterances of these [Φ] sounds are rather unstable as they are not pronounced in the traditional Japanese syllables, but only in the loan words, and some speakers who are familiar with the pronounciation of English produce the [Φ] sound by pulling the lower lip backward and by touching it to the upper teeth, instead of by protruding and rounding the lips. These [Φ(f)] sounds which are pronounced close to [f] have a shorter duration of friction compared with the sound [Φ], and begin with a plosion in some syllables. However, they are different from the English [f] sound which has a longer and clearer friction.

In the soundspectrograms of the syllables in the [w] row, it is also shown that the transition of format frequencies from the consonant to the following vowel correspond well to those of the [Φ] row.

Application to the Lipreading of [Φ] and [w] Sounds

In the traditional method of teaching lipreading in Japanese, it had been said that the sound [w] which appeared only in the syllable /'wa/ was able to be recognized by the sudden change in the mouth shape from

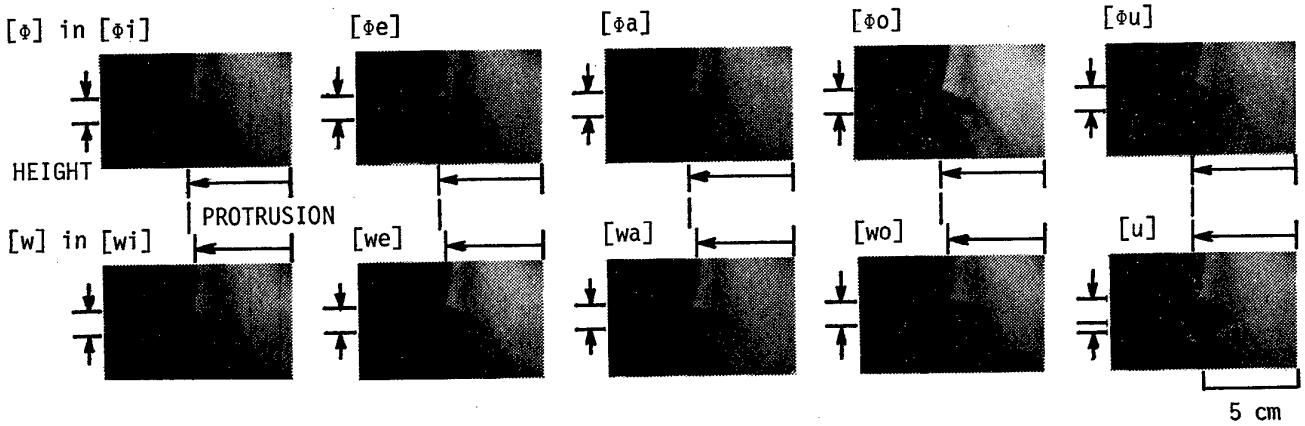

Fig. 1 Stroboscopic pictures of the mouth shapes of [Φ] and [w] sounds in the utterance of syllables in the [Φ] and [w] rows.

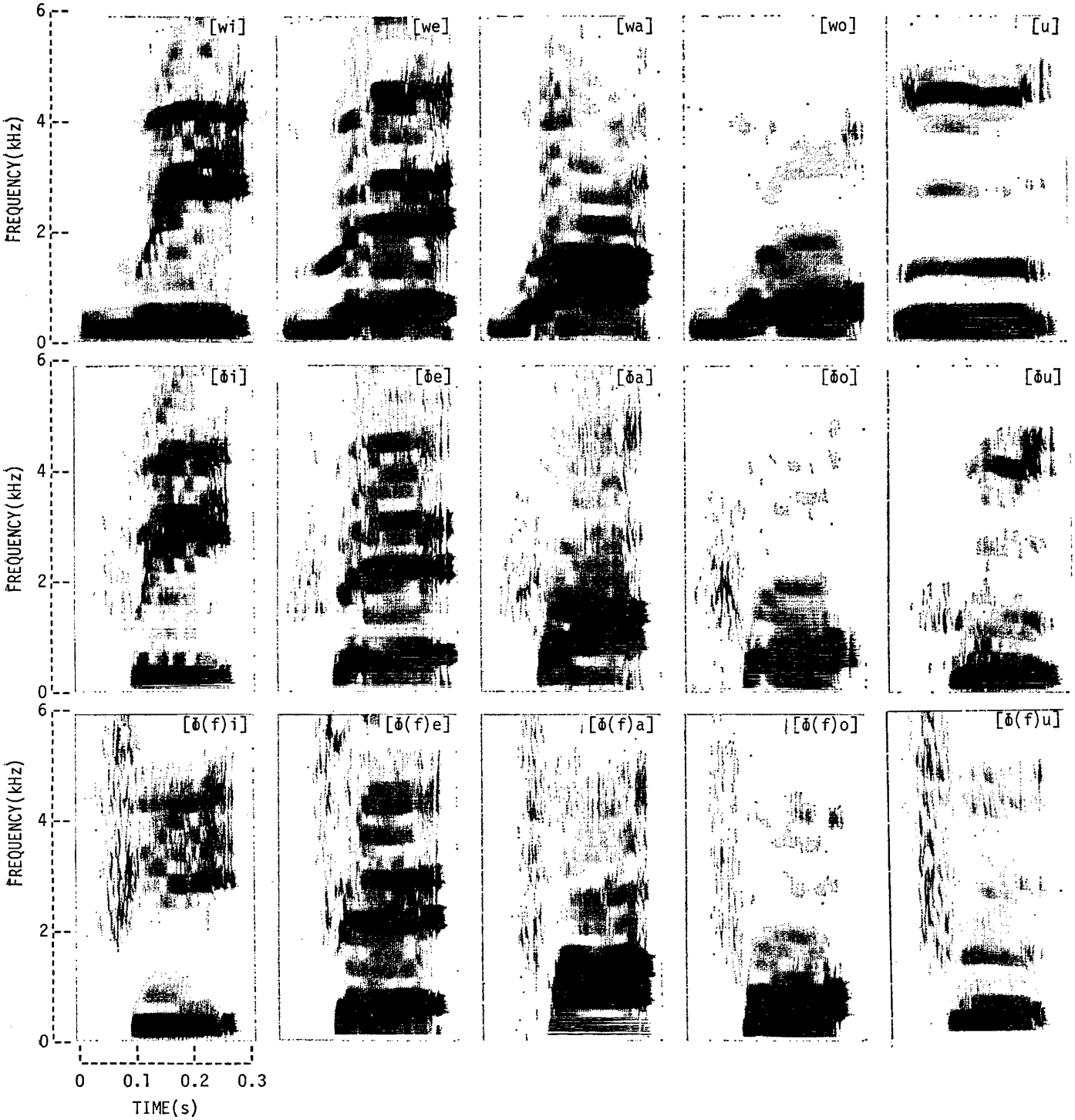

Fig. 2 Soundspectrograms of the [Φ], [Φ(f)] and [w] sounds in the syllabic utterances followed by the five Japanese vowels.

[w] to [a], except when it was preceded by the vowel /u/ and became homophonous to a syllable /a/. The stroboscopic pictures show that the characteristic mouth shape of [w] sound is also distinctive when [w] sound is followed by vowels [i], [e] and [o] in the syllables for the loan words.

The mouth shape of the [Φ] sound had been neglected, as it appeared only in the syllable /hu/, in which the [Φ] was followed by vowel /u/ having a similar mouth shape, and it resulted in a homophonous syllable of /u/. However, even in the utterance of the sound [Φ] embedded in a rather difficult context, [ju : Φo : da] (which means "An UFO!") for example, the mouth shape of [Φ], having narrower lips than [u], can be read clearly (Fig. 3). If this characteristic mouth shape failed to be noticed, the word could not be distinguished

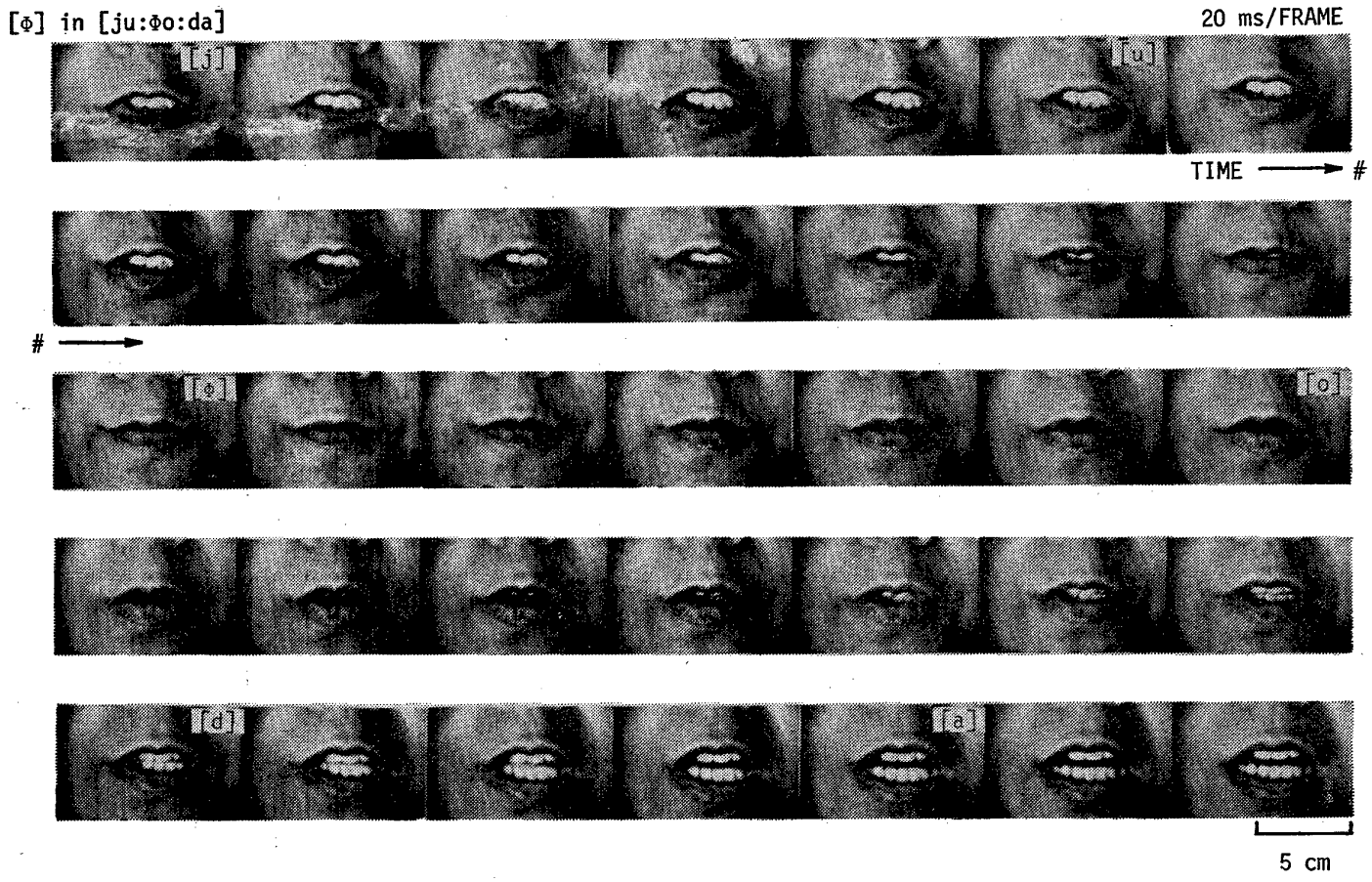

Fig. 3 Stroboscopic pictures of the mouth shape of the [Φ] sound in the context [ju : Φo : da].

from many other words such as [ku:ko:da] (which means "Here's an airport!"), [rju:ko:da] ("This is in fashion!"), [ʃukko:da] ("Set sail!") and [dʒu:jo:da] ("It is important!").

Even under ordinary conditions of lipreading, where distinct utterances and sufficient lighting are not available, the characteristic mouth shape of the [Φ] and [w] sounds may be readable when they are preceded by open vowels [a] and [e], and also when preceded by the rounded vowel [o] and the narrow vowel [i], Japanese choked sound /Q/ and syllabic nasal /N/ if followed by the open vowels. Hence, although it is not possible to differentiate the mouth shapes between [Φ] and [w] sounds, they can be identified as a group for more than half of the loan words which involve [w] and [Φ] sounds. This would serve to improve lipreading of modern Japanese if lipreaders were to aware of this.

References

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2) *Standard Japanese Dictionary* (Iwanami, Tokyo, 1974).
3) *The List of 540 Thousand Most Frequent Words Drawn from the Ninety Magazines Today* (National Language Research Laboratory, Tokyo, 1962).