An acoustic study of the Japanese voiceless bilabial fricative

Scott Ruddell

San Francisco State University

Abstract

In the past it has been widely accepted by Japanese linguists that the phoneme /h/ is phonetically realized as a bilabial fricative [ɸ] before /u/ (Akamatsu 1997; Inozuka, H. and Inozuka, E. 2003; Kashima 2002; Kase 2001). Recently, however, both Japanese and non-Japanese linguists have questioned whether Japanese speakers pronounce /hu/ as [ɸɯ] or in a matter which is closer to [hɯ] (Maddieson 2005, Watanabe 2009). Additionally, with the prevalence of loan words in Japanese, the bilabial fricative was established as the phonetic consonant in /fV/ sequences, causing a phonetic merger between /hu/ and /fu/, and making matters only more confusing.

This paper aims to reveal acoustic qualities in the pronunciation of /fu/ and other/fV/ sequences in native speakers of Japanese in order to attempt to reveal acoustic qualities of the Japanese /f/ sound, which have had very little acoustic research.

Ten native speakers of Japanese were asked to read from a word list containing both native Japanese words and loan words beginning with /f/. The auditory perception of the pronunciation of the /f/ sound was cataloged, and each sound was compared with the visual patterns in the spectrogram of the recording.

The results showed a variety of sounds occurring as /f/, including an interesting consonant which seemed to be a blend between [ɸ] and [h], implying that there can be no concise label of the phonetic realization of /f/. Therefore, what has been previously considered as the bilabial fricative in Japanese, should be studied empirically in the future, and be considered for re-categorization.

1. Introduction

The voiceless bilabial fricative [ɸ] is a rare sound found in less than seven percent of the world's languages (Maddieson 2005). In Japanese, conventionally the voiceless bilabial fricative has been categorized in a clear-cut manner as an allophone of /h/ in complementary distribution with [h] and [ç], where [ɸ] occurs in front of /u/. (Vance 1987, Tsujimura 1996). However, with the influx of loan words post-World War II, the voiceless bilabial fricative began to occur before all five vowels of Japanese. Consequently, it was split into two varieties in Japanese: the conservative variety, /hu/(or /fu/); and the innovative variety, found in the other /fV/ sequences (Vance 1987, Watanabe 2009). While most linguists claim that the consonants in these sequences are both pronounced with the bilabial fricative (Akamatsu 1997; Inozuka, H. and Inozuka, E. 2003; Kashima 2002; Kase 2001), Watanabe (2009) challenges the traditional idea, asserting that the conservative /hu/ is pronounced in a matter which is closer to [h].

In this paper, in order to unravel some of the issues revolving these sounds, we will investigate the acoustic phonetic qualities of Japanese /f/ sounds elicited through ten native speakers of Japanese reading from a list which was comprised of the traditional /hu/ sequence and innovative /fV/ sequences.

2. Background

The Japanese language consists of mostly CV sequences with only a few exceptions of sequences containing syllable final consonants. Besides the semi-vowels of Japanese ([j] and [w]), each of the fifteen syllable-initial phonemic consonants can come in front of each of the five Japanese phonemic vowels, /a/, /i/, /u/, /e/, and /o/. Therefore, on a phonemic level, possible consonant-vowel sequences in Japanese can be organized in a fairly simple way on a chart which has five rows corresponding each to vowel, and fifteen columns corresponding to each consonant. For example, "k-line" would consist of five CV sequences: /ka/, /ki/, /ku/, /ke/ and /ko/. However, when considering the allophonic sequences of some phonemes in Japanese such as in "h-line," categorization becomes more complicated.

2.1 h-line

Just like "k-line," "h-line" can be divided into five phonemic CV sequences: /ha/, /hi/, /hu/, /he/, and /ho/. However, when considering the phonetic representation we can see that each sequence is not actually articulated with the phonetic sound [h], as seen in the chart in Figure 1 below.

	/ha/	/hi/	/hu/	/he/	/ho/
ha-gyō sequences	[hɑ]	[çi]	[ɸɯ]	[he]	[ho]

Figure 1: The traditional phonetic representations of h-line, otherwise known as "ha-gyo" *(Watanabe 2009: 86)*

Notice how the phonetic representation of /h/ in front of /u/ as well as /i/ is not actually [h]. The IPA symbols [ɸ] and [ç] represent the voiceless bilabial fricative and voiceless palatal fricative respectively.[1] Linguists have in the past agreed upon the phonetic representation of /hu/, claiming that it is articulated with an [ɸ], and have agreed upon the rule: /h/ becomes [ɸ] in front of /u/ in non-innovative sequences (Vance 1987, Tsujimura 1996).

2.2 f-line

We have observed that [ɸ] is an allophone of the phoneme /h/ which only occurs before /u/. However, in words borrowed from other languages (hereinafter loan words); the phonemic distribution of /ɸ/ becomes less straightforward. In Figure 2 we can clearly see that [ɸ] may also occur in front of the four other vowels.

[1] For the purpose of this paper, we will only be dealing with the voiceless bilabial fricative.

	/fa/	/fi/	-	/fe/	/fo/
fa-gyō sequences	[ɸɑ]	[ɸi]	([ɸɯ])	[ɸe]	[ɸo]

Figure 2: The phonetic representations of f-line sequences. (Watanabe 2009:86)

What was pronounced with the voiceless labio-dental fricative [f] in the original language (namely English) becomes [ɸ] in [ɸa], [ɸi], [ɸe], and [ɸo] sequences (Katayama 1998). Below is a list of example loan words, and their phonemic representations, borrowed into Japanese from English

(1) /ɸan] "fan"
/ɸirumu/ "film"
/ɸeruto/ "felt"
/ɸorio/ "forio"

Due to the fact that Japanese does not have [f] in its phonetic inventory, words which begin with [f] from a language such as English are inevitably pronounced as [ɸ] by Japanese speakers since [f] and [ɸ] have similar places of articulation (Tsujimura 1996).

The problem that this brings is that [ɸ], which was previously considered just an allophone of /h/ in complementary distribution, now occurs in front of all five vowels and may possibly be considered a separate phoneme in this sense.

2.3 Japanese Loan Word Phonology

In order to understand the phonetic controversy around this sound it is important to look at Japanese loan word phonology. We have already established that "[ɸ] occurs only when /h/ is followed by the high back vowel /u/" (Tsujimura 1996: 37). Consequently, we would expect the phonotactic constraints to disallow [ɸ] before any other vowel besides /u/. Yet we have seen in the previous sections that [ɸ] does occur before innovative /fV/ sequences.

When a recipient language borrows a word from the source language, it is required that a language has a way to deal with foreign sounds which are not in its phonemic inventory (Davis 1994). This is shown in the process in which [f] changes to [ɸ] in Japanese. Not only are phonemes of the recipient language maintained, but the *sequences* in which those phonemes occur are also often preserved (Davis 1994; Kang 2011). In other words, phonotactic constraints are usually what determine how loan words will be adapted into the recipient language.

Vance (1987) and Akamatsu (1997) both mention that conservative speakers of Japanese insert an /u/ in between /ɸ/ and non /u/ vowel sequences,[2] which would be consistent with the phonotactic constraints of traditional Japanese. However, it is stated that in current Japanese speech, that there is no /u/ is inserted in the pronunciation of innovative /fV/ sequences and [ɸ] is pronounced in combination with any vowel (Vance

[2] For example, /ɸirumu/ "film" becomes [ɸɯirumu]

1987, Tsujimura 1996, Akamatsu 1997), but there is virtually no explanation as to how this transition happened, which raises questions in both a phonetic and phonemic sense.

Lovins (1975) makes the assumption that Japanese people have become more bilingual over time, which may play a role in the transformation of the phonotactic constraints of loan words, but this does not seem to be a sufficient enough explanation.

More recently, Optimality Theory phonologists proposed using constraint-base rankings to explain unique consonant-vowel combinations in loan words. Instead of the previous belief that there is a distinct component in loanword phonology, they suggest rather that complex patterns of loan words are "derived through the interaction of constraints which are independently motivated in the language" (Yip 1993, Ito and Mester 1995a&b, cited in Katayama 1998).

Although these phonological issues are important to look at, we will be more focused on the more straight-forward phonetic qualities of [ɸ] in this paper.

2.4 Controversy over the articulation of native /hu/

Most linguists agree than the phonetic realization of /hu/ is [ɸɯ][3] (Akamatsu 1997; Inozuka, H. and Inozuka, E. 2003; Kashima 2002; Kase 2001). For example, Akamatsu states that "both lips are involved in the articulation of [ɸɯ]" (Akamatsu 1997:88). Furthermore it is often stated that by these linguists that /hu/ is articulated as if blowing out a candle, emphasizing lip frication, and in doing so, stating that /hu/ is articulated as [ɸɯ].

Watanabe (2009), on other hand, steps away from the traditional view, arguing that /hu/ is not actually pronounced as [ɸɯ], but rather is pronounced in a matter which is closer to [hɯ], and emphasizes the lack of lip activity and lack of air flow needed in the articulation of /hu/. The lack of lip activity is supported by the study done by Löfqvist (2005) who examines lip movement in bilabial consonants. His data included a few Japanese foreign loan words containing [ɸ], and the results showed very minimal lip movement. Maddieson (2005), who studied the voiceless bilabial fricative in the West-African language Ewe, states in regard to Löfqvist's study that the Japanese voiceless bilabial fricative shows very little frication compared to Ewe's bilabial fricative, and should rather be considered an approximant. Uehara and Kiyose (1974) also agree the /hu/ is pronounced closer to [hɯ], describing the articulation of the fricative in /hu/ as a similar manner to that of the British pronunciation of "wh" in "who."

Watanabe (2009) states that innovative /fa/, /fi/, /fe/, /fo/ sequences require more lip movement and airflow compared to conservative /hu/, and are therefore pronounced with the voiceless bilabial fricative.

One more point which is important to mention is that Akamatsu (1997), who supports that /hu/ is pronounced with the bilabial fricative, even suggests for learners of Japanese who have trouble pronouncing the bilabial fricative and end up pronouncing the sound as an [f], to pronounce/hu/ with an [h] in order to sound more natural. This elicits that there is a connection, at least in a perceptual sense, between [ɸ] and [h].

[3] [ɯ] is the IPA representation of the non-rounded high-back vowel

2.5 History of [ɸ]

According to Watanabe (2009), much of the confusion of the pronunciation of /hu/ is due to historical reasons. The voiceless bilabial fricative is said by Japanese linguists to have gone through a process called "labial lenition" (Hashimoto 1950; Inozuka and Inozuka 2003; Watanabe 2009). This theory states that in the past there was in fact no /h/ sound or /ɸ/, but only a /p/ sound. Over time, this /p/ became "weaker," and instead of a voiceless labial stop became a voiceless bilabial fricative. Therefore at a point in time [ɸ] came before all five vowels at native-word level. In the past few hundred years the labial lenition continued to the point where [ɸ] became [h], but according to Shibatani (1990) the evolution was partially stopped at /ɸ/ where /ɸ/ precedes /u/.[4] This evolution which stopped at /u/ has seemed to have created what Akamatsu (1997:142) refers to as the "inherent combinability of [ɸ] and [ɯ].

2.6 Vowel Devoicing

One last topic which must be touched upon is a phenomenon in Japanese which is known as vowel devoicing. The general rule states that: high vowels become devoiced between two voiceless obstruents or word-finally after a voiceless obstruent (Vance 1987). Additionally devoicing generally only occurs in unaccented vowels (Han 1962:81, cited in Vance 1987). Saito Yoshio (2003, cited in Watanabe 2009) states that [ɸ] always appears when followed by a voiceless vowel [ɯ̥] mentioning examples such as as [ɸɯ̥kɯ] (/huku/ "clothes"), and is therefore significant when examining the pronunciation of /hu/.

3. Methods

Ten native speakers Japanese were used as subjects. The subjects varied in: age range, birthplace, and bilingualism. Information about the speakers is listened in Table 1 below.

ID	Sex	Age Range	Birthplace	Years of English Study	Years in America
1	F	20-30	Ibaraki	8	0.5
2	F	20-30	Akita	10	0.5
3	F	20-30	Akita	9	1.5
4	F	20-30	Tokyo	13	1.5
5	M	20-30	Hokkaido	12	2.5
6	M	30-40	Aichi	11	6
7	F	40-50	Kobe	30+	6
8	F	30-40	Aichi	15	10
9	F	40-50	Osaka	30+	15
10	F	50-60	Tokyo	30+	30+

Table 1. Speakers Information

[4] A similar occurrence happened for /hi/ in which /h/ became the voiceless palatal fricative [ç]

The speech data was elicited by having speakers read a list of Japanese words which were included to provide the target sound /ɸ/ in front of each of the five Japanese vowels. Additionally, words containing environments predicted to cause vowel devoicing were included. Due to the limited scope of this paper, intervocalic /ɸ/ sounds were not observed. The words are listed in Table 2 below.

Word	Meaning	Word Type
/**Fa**n/	fan	Loan
/**Fi**rumu/	film	Loan
/**Fe**ruto/	felt	Loan
/**Fo**rio/	folio	Loan
/**Fu**kadakku/	(Co. Name)	Loan
/**Fu**kushia pinku/	Fuschia	Loan
/**Fu**tarusan/	phthalic acid	Loan
/**Fi**sukaru porishii/	fiscal policy	Loan
/**Fi**tokuromu	phytochrome	Loan
/**Fu**shigi/	mysterious	Sino-Japanese
/**Fu**ton/	futon	Sino-Japanese
/**Fu**an/	anxiety	Sino-Japanese
/**Fu**ne/	boat	Native Japanese
/**Fu**ku/	clothes	Native Japanese
/**Fu**ufu/	couple	Sino-Japanese

Table 2. Word lists with their phonemic transcriptions, meaning, and word type

Each word was produced within the carrier phrase:

"Sore wa ____desu"
That TOPIC is
"That is _____."

All of the speakers were asked to read out the words listed within the carrier phrase at a natural pace, and with a pause after the topic marker "wa." Recordings were taken using the program "Audacity" and a Samson Q1U USB Microphone.

The data was analyzed by first cataloging the perceived word-initial consonant. Further analysis was taken using the software "Praat." Amplitude was measured for each of the following ranges: 1kHz – 7kHz, 7kHz – 13kHz, and 13kHz – 20kHz. Amplitude levels were taken with a spectral slice function in Praat. Due to fact that I could not obtain consistency in the speaker's loudness and distance from the speaker's mouth to the microphone, I could not quantify absolute amplitude. However relative amplitude was measured through a system in which decibel ranges were placed into the following four categories:

Category ***Amplitude Range***
(1) Prominent: 20dB or more
(2) Moderate: 10dB – 20dB
(3) Weak: 1dB ~ 10dB
(4) None: 0dB or less

In addition to amplitude, spectrograms were observed in order to search for connections between auditory qualities of the perceived sound and spectral patterns.

My expectations were that [ɸ] and [h] would occur based on the traditional treatment and Watanabe's (2009) unconventional treatment of the pronunciation of /hu/ and /fV/ sequences. I expected that older generation speakers would more commonly insert /u/ between /f/ and non-/u/ vowels, and that there would be a possible correlation between /u/-insertion and age.

4. Results

Figure 3 shows the perceived word-initial consonants for each word and the number of speakers who uttered that perceived consonant. The results show that four distinct sounds were uttered by the speakers. Consistent with our expectations, [ɸ] and [h] occurred. Contrary to our expectations, [f] was also shown in the pronunciation of some speakers. Additionally a consonant which I have labeled as [ɸ/h] was observed. This sound had qualities of both [ɸ] and [h], but was unique enough to receive its own category.

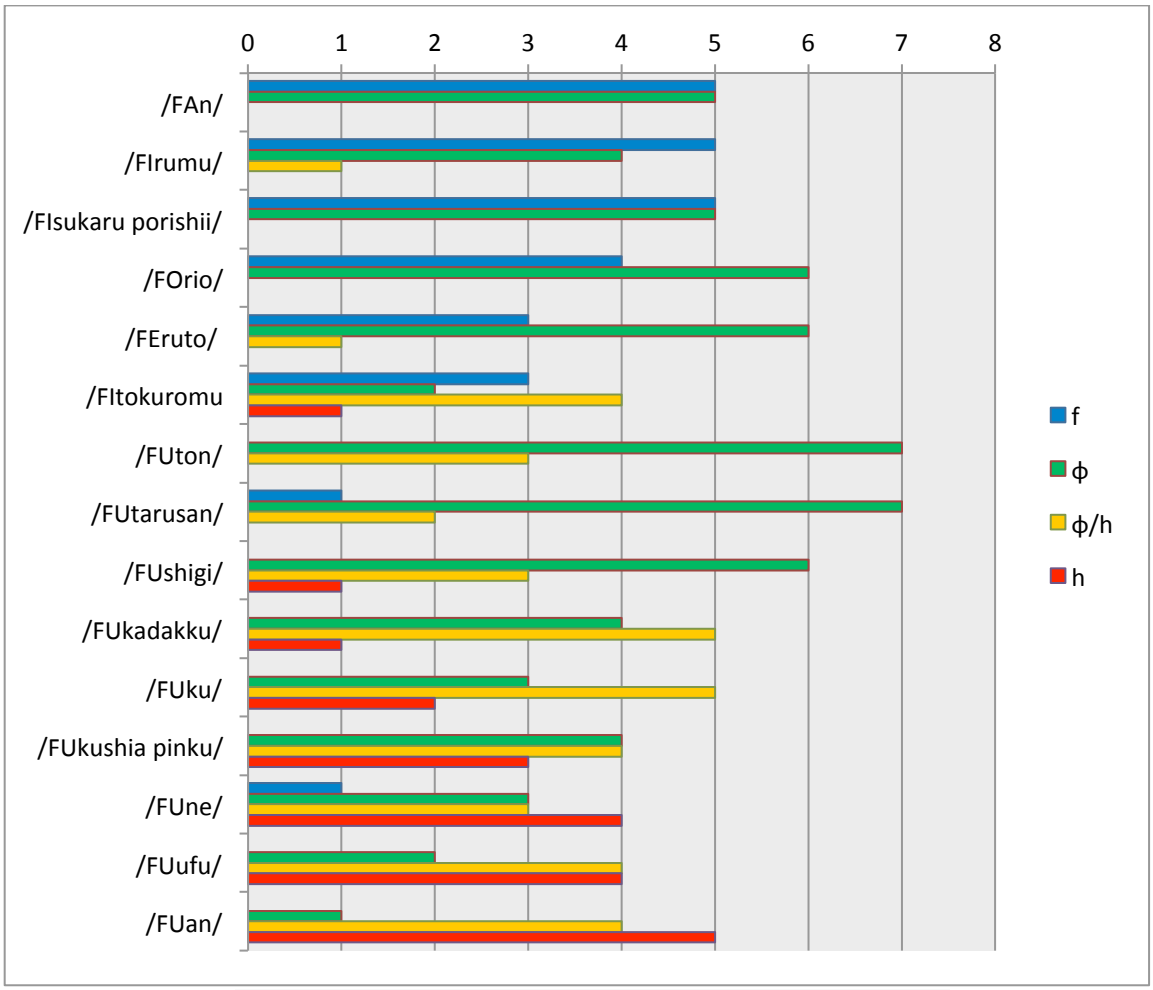

Figure 3. Perceived sounds and amounts of speakers

The words in the graph in Figure 3 have been arranged to be able to see the patterns correlating between the environment of /f/ and the sound which was uttered. For example we can see that the number of speakers that uttered [f] was much higher in /fa/, /fi/, /fe/, and /fo/ sequences; [h] on the other hand occurred nearly exclusively before /u/.

As expected, [ɸ] and [ɸ/h] occurred more often in environments which vowel devoicing occurred (e.g /fu**t**arusan/ "pthatlic acid"). The sounds that followed /fu/ sequences also seemed to affect which sound was uttered. If we look at words starting from /futon/ "futon" and down, you can see that [ɸ] occurred more often in /fu/ + an alveolar consonant sequences (e.g. /fu**t**arusan/ "pthatlic acid" or /fu**s**higi/ "mysterious"), and less often in /fu/ + velar consonant sequences (e.g. /fu**k**u/ "clothes"), while the number of utterances of "[ɸ/h] increased in the /fu/ + velar consonant environment. Additionally we can see that [h] was the most common in /fV/ + nasal sequences (i.e. fu**n**e) and /fVV/ sequences (e.g. /fu**a**n/ "anxiety).

There were only two apparent occurrences of /u/- insertions seen where [ɸ/h] occurred in /firumu/ "film" and /feruto/ "felt." There was therefore no correlation between age and /u/-insertion, but the utterance was rather just dependent upon the individual's preferred pronunciation.

4.1 [f]

As expected, [f] was rarely shown in Japanese native words. In other words, [f] only occurred before vowels which were not /u/.[5] Speakers who were more proficient in English tended to be the ones who uttered [f] in loan words. These speakers also tended to have more years spent in America compared those who did not utter [f]. Figure 4 shows the spectrogram of a typical looking [f] sound.

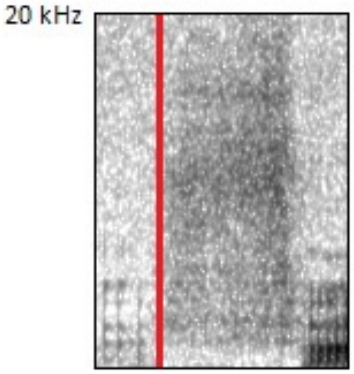

Figure 4. Spectrogram of [f]

Spectral patterns shown in [f] were mainly (1) an abrupt start to the consonant indicated by the red vertical line added to the spectrogram in Figure 2, and (2) significant amplitude shown in the range of 13 kHz to 20 kHz, indicating that [f] often had higher frequency noise. The graph in figure 3 shows the breakdown of amplitude at each of the three frequency ranges.

[5] Except in two cases. This can be justified by Vance (1987) who states that sometimes Japanese speakers have some dental frication in the utterance /f/ words, particularly in the word /fune/ "boat."

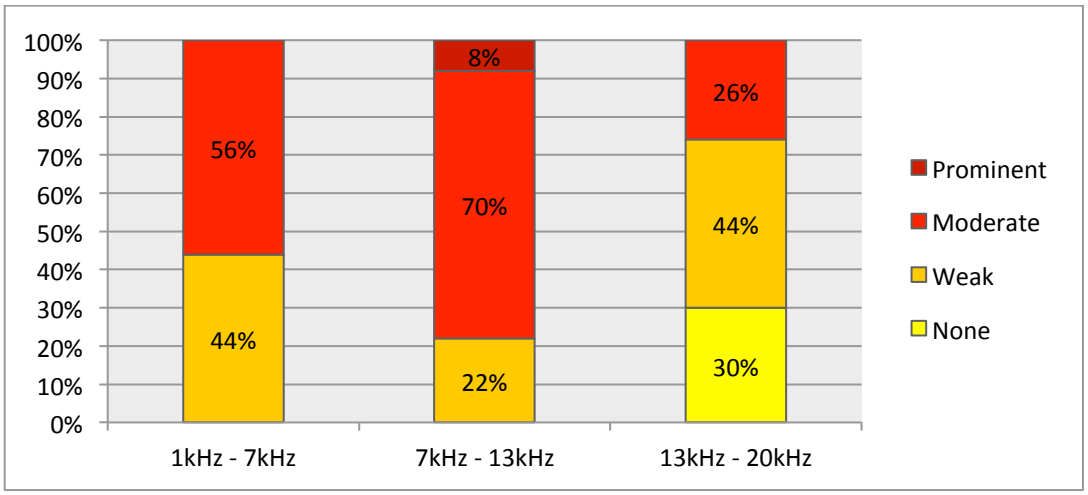

Figure 5. Amplitudes of the three different frequency ranges in [f]

The fact that [f] was uttered by Japanese speakers —despite that it is not in the Japanese phonetic inventory—suggests the occurrence of what Haugen (1953) calls "linguistic overlap," which occurs when "two systems are simultaneously applied to a linguistic item" (Haugen, 1953, as cited in Lovins, 1975). The degree of bilingualism, which although cannot be measured easily, is what seemed to affect whether [f] or [ɸ] was uttered before non-/u/ vowels. This can be attested by McMahon (1994) who states: "language contact and lexical borrowing depend on bilingualism, and the degree of bilingualism required for lexical borrowing varies from "very restricted" to "far-reaching"" (McMahon 1994, as cited in Watanabe 2009).

4.2 [ɸ]

Unlike [f], which was limited to mainly to the innovative variety of /fV/ sequences, [ɸ] occurred before both conservative /fu/ and innovative /fV/ sequences. Amplitude levels of [ɸ] are seen in Figure 6 below.

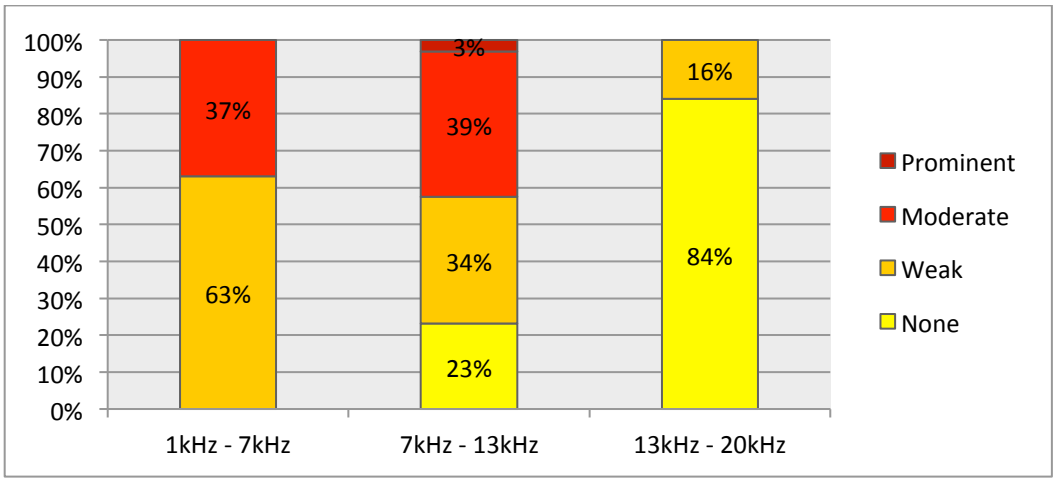

Figure 6. Amplitudes of the three different frequency ranges in [ɸ]

From Figure 6 we can see that at the 7kHz to 13 kHz range there is a variation of amplitudes. This seemed to be mainly based on whether the [ɸ] occurred in /fu/ or innovative /fV/ sequences. In this frequency range, sounds which were labeled as "prominent" or "moderate" usually occurred before /u/. Conversely, sounds that were labeled as "weak" or "none" usually occurred before vowels other than /u/. However, this is most likely being caused by co-articulatory effects dependent upon the vowel, therefore it is not enough evidence to prove that [ɸ] before /u/ is significantly different from the when it occurs before the other four vowels.

Since most the most significant variation occurred before /u/, from this point on I will focus on the fricatives in their /u/ environment. Below, in figure 7 is a spectrogram of [ɸ] in a /fu/ sequence.

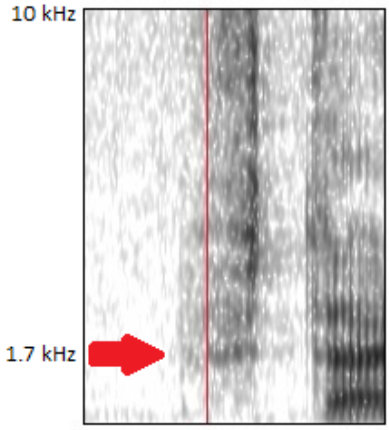

Figure 7. Spectrogram of [ɸ]

From Figure 7 we can see a dark formant band to the right of the red vertical line at about 1.7kHz. This formant band presumably represents lip rounding in anticipation for the following /u/ sound. Notice that to each side of the red line there is a contrast in amplitude; and particularly on the left side of the red line there virtually no sign of the prominent band. My intuition was that this indicated lip movement in the articulation of this sound, seemingly caused by partial lip closure in the initial utterance of [ɸ] (hereinafter initial lip closure). This sign of initial lip closure was seen in the majority of sounds which were perceived as [ɸ], regardless of the following vowel.

4.3 [ɸ/h]

The most difficult fricative to perceive by ear was what I have categorized as a blend between both [ɸ] and [h]. From Figure 9 we can see that unlike [ɸ] there is no contrast in amplitude around the prominent formant band. Rather, the formant band which shows the lip rounding of the anticipation of /u/ is visible even from the initial utterance of this sound. This suggests there was little initial lip closure or lip movement involved in the articulation of this sound. Rather, the speaker must have had a more steady lip position throughout the whole articulation of the sound.

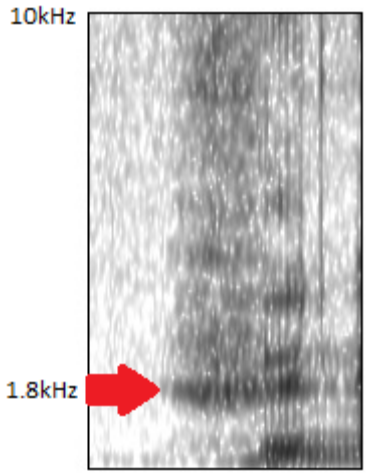

Figure 9. Spectrogram of "[ɸ] ~ [h]"

The prominent band (seen in Figure 9) which is existent even in the initial utterance of the sound consistently correlated to what I heard as a blend between [ɸ] and [h]. This characteristic, which is apparently representative of the steady lip position in the articulation of [ɸ/h], was the main characteristic which set it apart from [ɸ]. Figure 10 shows the analysis of initial lip closure in [ɸ] vs [ɸ/h] before /u/.

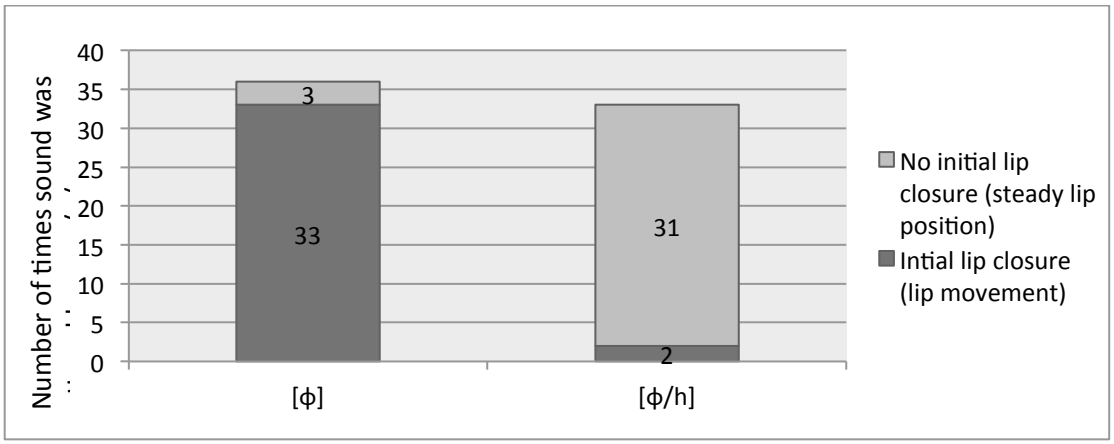

Figure 10. Lip closure in [ɸ] vs "[ɸ] and [h]."

We can clearly see that the majority of [ɸ] sounds were observed to have initial lip closure in the spectral patterns. Conversely, the majority of [ɸ/h] sounds did not show initial lip closure. These patterns showed in the spectrogram seemed to match with the auditory differences I heard between these two sounds.

[ɸ/h], apart from the observed lack of lip closure, was very similar to [ɸ], which can be accounted for by the similarities in the overall level of amplitude. Figure 11 shows the frication levels of [ɸ/h].

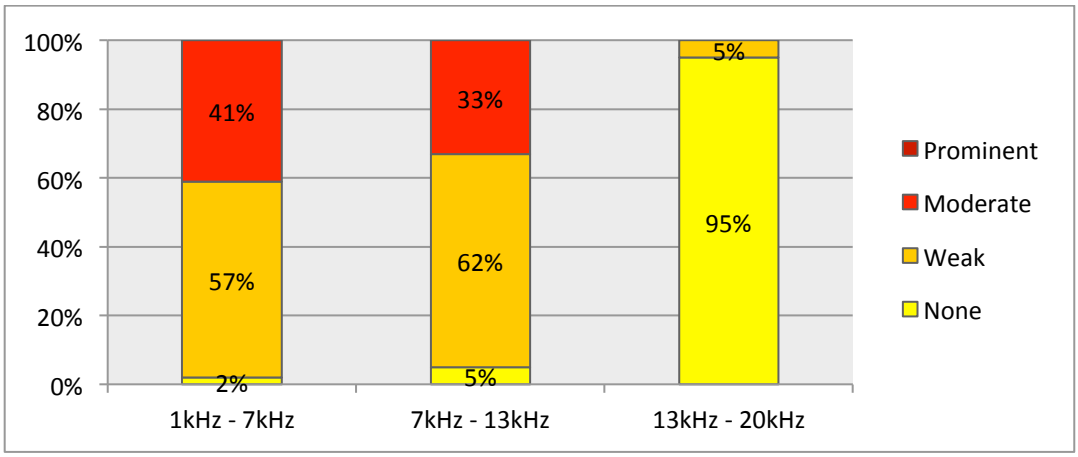

Figure 11. Amplitudes of the three different frequency ranges in "[ɸ] ~ [h]"

Similar to [ɸ], the majority amplitude levels for [ɸ/h] were: "weak" or "moderate" in the range of 1kHz to 7kHz and the range of 7kHz to 13kHz, and were "none" in the range of 13kHz to 20kHz.

In opposition to [h], higher amplitude levels were what set the [ɸ/h] apart from [h]. [ɸ/h] had significantly greater frication and could not be put into the same category as [h]. However, [ɸ/h] had an undeniable [h]-like auditory quality which may be accounted for by the steady lip position held by the speakers when articulating this sound.

4.4 [h]

Unlike [ɸ/h], [h] itself was easy to recognize by both its sound and its spectral shape. On a spectrum of frication, [h] would be considered the polar opposite of [f] in that it showed little to no frication besides a similar band to the one found in [ɸ] and [ɸ/h] at the 1 kHz to 3 kHz range. [h] also showed very limited environments, nearly always occurring before /u/.[6] Figure 12 shows the spectrogram of [h] before /u/.

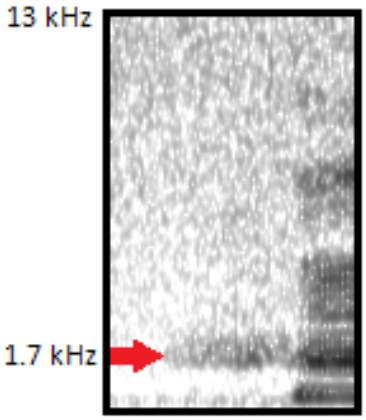

Figure 12. Spectrogram of [h]

[6] Only 1 incident was not in front of /u/.

We can see from the spectrogram in Figure 12 that the same prominent band from 1 to 3kHz that was shown in [ɸ] and [ɸ/h] is also shown in [h]. As I have stated earlier, this seems to be indicating lip rounding, while the lack of noise outside of this prominent band is indicating that there is very little frication caused the lips. The low amplitude levels are apparent in Figure 13.

Figure 13 shows the frication levels of all of the [h]'s that were uttered. [7]

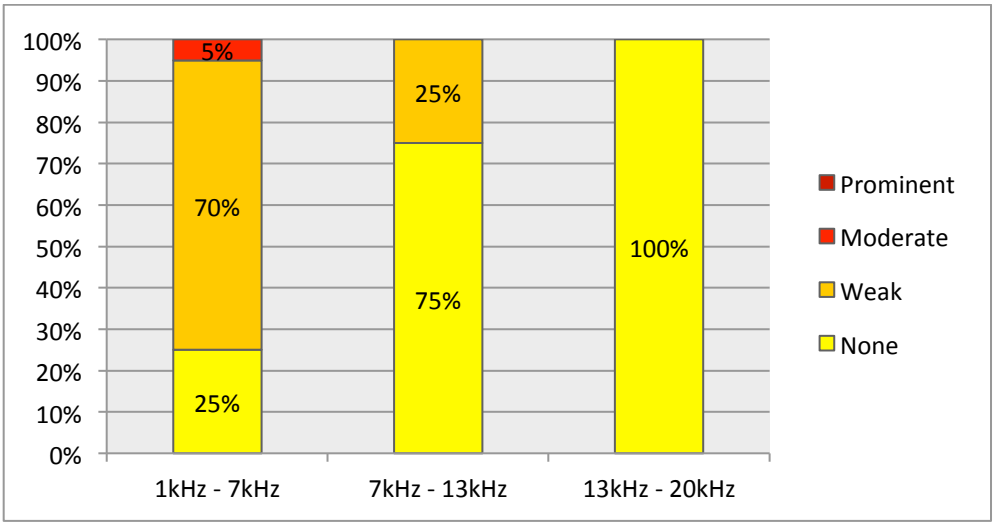

Figure 13. Amplitudes of the three different frequency ranges in "[h]"

Out of all the sounds observed, [h] by far had the lowest amount of overall frication, and was uttered by those who had weak frication throughout all the words. These speakers who showed weak frication were generally younger generation speakers from the Tokyo area.

5. Conclusions and further studies

The occurrence of four distinctive vowels exceeds our expectations which only included two sounds: [ɸ] and [h]; and suggests that the /f/ sounds of Japanese are possibly even more complex than originally thought. However, [f] can be considered an irregularity of Japanese for the most part, and was uttered due to linguistic overlap caused by bilingualism.

Perhaps the most significant sound which occurred was the blend between [ɸ] and [h]. The contrast between this blended sound and the voiceless bilabial fricative evidently was caused by a lack of lip movement in the utterance of [ɸ/h] versus lip movement in the utterance of [ɸ]. This finding supports Watanabe (2009) who mentions the occurrence of lip movement in innovative /fV/ sequences where he believes [ɸ] occurs, as well as the lack of lip movement in conservative /hu/ where he believes a sound closer to [h] occurs. In fact, the blended sound seems to match well with Watanabe's (2009) description of the pronunciation of /hu/, as I believe this blended consonant sounds more like an [h] than it

[7] Amplitude levels do not include the prominent formant band.

does a [ɸ]. In fact, we may consider this sound to be transcribed as [h^{w}] in order represent the extra labialization causing extra frication in the pronunciation of this sound.

Additionally, the occurrence of the phonetic [h] even further elicits the idea that /hu/ is pronounced closer to [h] than [ɸ]. We saw that quite often this [h] was found in the utterances of younger generation speakers from the Tokyo area. The Tokyo area is where the so-called "standard Japanese" exists, so if we would like to have the most up-to-date characterization of Japanese phonetics, younger generation speakers from the Tokyo area would be a prime area to conduct research, and therefore opinions of linguists may change regarding the pronunciation of /hu/.

The main implication from this paper is that /f/ sounds in Japanese cannot be categorized with only the voiceless bilabial fricative as it has been in the past. In order to understand the various /f/ sounds of Japanese in the future there should be more studies empirically examining the acoustic signals, articulatory gestures, lip movement, and airflow which revolve around /hu/ and innovative /fV/ sequences. By doing so, we can more accurately understand these sounds, and therefore more accurately categorize the sounds in Japanese.

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