

## Problem Set 5 Solutions

### Problem 1

(a) The two shortest and two longest vowels in each utterance are listed below\*

Speaker	Shortest Vowels (duration, ms)	Longest vowels (duration, ms)
J (F)	/ə/ “the” (20); /ə/ “a” (25)	/i/ “cookies” (160); /ə/ “con-“(143)
K (M)	/ə/ “con-” (30); /ə/ “the” (22)	/e/ “-tain” (130); /ɔ/ “box” (123)
M (M)	/ə/ “a” (22); /ə/ “the” (25)	/e/ “-tain” (143); /i/ “-kies” (108)
S (F)	/ə/ “the” (23); /ə/ “a” (35)	/e/ “-tain” (133), /ɔ/ “box” (131)

\*answers may vary

(b) Frequencies of the major peak in /k/’s are listed.

Speaker	1 <sup>st</sup> /k/, “ <u>box</u> ”	2 <sup>nd</sup> /k/, “ <u>cont</u> ain”	3 <sup>rd</sup> /k/, “ <u>coo</u> -“	4 <sup>th</sup> /k/, “- <u>kies</u> ”
J	1733 Hz	2237 Hz	1575 Hz	2646 Hz
K	1607 Hz	2331 Hz	1008 Hz	2489 Hz
M	1670 Hz	2426 Hz	1229 Hz	2583 Hz
S	1260 Hz	1985 Hz	1103 Hz	2552 Hz

The front-cavity resonances for the female speakers, except for /k/ in “contain”, are higher than those of the male speakers. This makes sense because the female vocal tract is shorter, thus the resonant waves have shorter wavelengths and higher frequencies.

The adjacent vowel also determines location of peak frequency. When the tongue body for the adjacent vowel is front and high, such as in “-kies”, the resonant frequency is high. When the following vowel is rounded, high and back, such as in “coo-“, the peak frequency is very low. When adjacent to a low back vowel such as in “box”, the peak frequency is in between those of “-kies” and “coo”.

(c)

(i) Frequency and Amplitude (in dB) of the peak at high frequencies (above 3500 Hz)

Speaker	/s/, “ <u>box</u> ”	/s/, “ <u>just</u> ”	/z/, “ <u>cookies</u> ”	/f/, “ <u>few</u> ”
J(F)	5576; 31.1	5765; 31.8	6332; 18.5	3812; 30.8
K(M)	4347; 28.3	4064; 27.9	3875; 31.8	3497; 19.4
M(M)	4001; 29.5	5072; 24.3	4820; 30.5	3560; 8.8
S(F)	5198; 24.8	5324; 27.8	6143; 18.2	4095; 12.3

- (ii) Maximum amplitude (in dB) in the range of the second and third formants (usually 1300 to 3000 Hz)

Speaker	/s/, "box"	/s/, "just"	/z/, "cookies"	/f/, "few"
J(F)	1701; 23.5	1985; 11.6	1953; 13.6	2331; 21.2
K(M)	2804; 34.4	2615; 24.2	2583; 20.8	2552; 25.2
M(M)	1701; 26.5	1670; 11	1670; 14.4	2615; 25
S(F)	1449; 15.7	1512; 10.5	2079; 12.8	2079; 20.5

- (iii) Difference in amplitude (dB) between (i) and (ii)

Speaker	/s/, "box"	/s/, "just"	/z/, "cookies"	/f/, "few"
J(F)	7.6	20.2	4.9	9.6
K(M)	-6.1	3.7	11	-5.8
M(M)	3	13.3	16.1	-16.2
S(F)	9.1	17.3	5.4	-8.2

For the alveolar fricatives, /s/ and /z/, the female high frequency peaks, according to text, should be 15-20% higher than the male's. The measurements agree with this. For the most part, the magnitude of the peak at high frequencies is greater than the peak between F2-F3, this makes sense, because the front cavity is quite short, so there is more energy in higher frequencies.

The labiodental fricative /f/, has less energy in the high frequencies than /s/. /f/'s spectrum has negligible amount of energy above 5 kHz, while /s/'s spectrum has many peaks in the 6-7 kHz range. Adjacent vowel may also affect the articulation of /f/.