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Analysis of Intonation Patterns in Urdu

Abstract: *Urdu has many interesting intonation patterns. Intonation can be used to indicate how the speaker feels about what he is saying, or express emotions like anger, joy, exclamation, tire, interrogation, satisfaction etc. An important feature of Urdu intonation is the use of extra stress to indicate the main focus of a sentence. This paper aims at presenting a detailed analysis of intonation patterns of Urdu regarding declarative and interrogative sentences. The variation in pitch and duration of fundamental frequency of a sentence differs due to gender differences, which is observed and the generalized syllable pattern map for declarative and interrogative sentences containing multi syllabic words is presented in this paper.*

1. INTRODUCTION

No language is spoken in monotone. All languages have variations in pitch, which we hear as the voice going up and down. These variations in pitch are sometimes called the "tunes" of a language, but more precisely are known as pitch patterns or *intonation patterns*. Speakers use intonation patterns to help them communicate their ideas. The rising and falling tones of language separate ideas, distinguish questions and sentences, and show special emphasis. As listeners, people become skilled at detecting fine shades of meaning in other people's speech.

Generally, if a person is not a native speaker of a language then even if each word is pronounced clearly but the intonation patterns are non-standard, the meaning will probably be ambiguous.

2. LITERATURE REVIEW

Research on intonation has long been characterized by a number of unresolved major issues and fundamental differences of approach. Within the past years, a widely accepted framework has emerged for the description of intonation phenomena. Since the mid-1970s several researches have converged on a set of broadly shared assumptions and methods. Studies on a variety of languages are now yielding new discoveries expressed in comparable terms.

Intonation patterns are specified as an abstract sequence of high and low tones (Ladd 1996). These tones have no absolute physical value. Rather, they are implemented relative to each other through the manipulation of pitch and the fundamental frequency (f0) of the voice.

According to the ToBI system, English intonations can be transcribed with three different kinds of tone: a pitch accent, a phrase tone, and a boundary tone. Each of these can be specified as either high or low, and minimally an utterance must contain one of each type.

(Goldsmith 1981) proposed that lexical stress could be characterized by a MHL auto segmental melody, in which the H tone corresponds with the strongest stress. (Liberman 1975) pursued the same approach to characterize intonation more generally. For example, he identified a LHM "calling" intonation, in which the H tone characterizes the main stress, and the initial L tone spreads on to all pre-stress syllables. (Pierrehumbert 1980) distinguished between different types of tonal targets and proposed to use H and L boundary tones at the beginning and end of major phrases, as well as a H or L phrase accent at the end of each intermediate phrase.

However no significant work has been done on analyzing the intonation patterns found in Urdu.

2.1. Intonation as a Prosodic Feature

Intonation is referred to as a prosodic feature of any language. It is a collective term used to describe variations in pitch, loudness, tempo, and rhythm. These features are all involved in intonation, stress, and rhythm.

2.2. Stress and Intonation

Stress is the relative prominence of syllables. Among the syllables of a word, one syllable usually stands out as more prominent than the other syllables. The stress position is determined by the structure of words and phrases in a sentence.

Stress is realized in several ways in languages of the world. The physical process for creating prominence on a syllable has many variations.

Fundamental frequency (f0), duration, and intensity are often common correlates of syllable prominence. In many languages, change in f0 can affect the accent of the speech (Hussain 1997).

2.3. Intonation in Urdu

Urdu is a very rich language with a multilingual and multicultural heritage, spoken and understood in many countries. Over sixty million people, speak Urdu. The estimate of the number of second language speakers of Urdu is one hundred four million. Each language deals with expressing emotional ranges and contextual importance in different ways. Some languages, such as French, stress the end of a sentence, and then use word order to indicate an important change. Other languages, such as Chinese, have a pitch change that indicates different vocabulary words. Urdu language has a number of intonation patterns which add conventionalized meanings to the utterance: question, statement, surprise, disbelief, sarcasm, teasing. In Urdu, at least one or more words are naturally stressed in a declarative sentence. For example in the declarative sentence given below the word /خوبصورت/ is stressed naturally.

/ ہے۔ شہر خوبصورت لاہور/

Removing natural stresses from a sentence makes it sound mechanical. By just changing the stressed word in a sentence, the meaning of the sentence can change. For example, changing the stressed word in the above sentence can make it interrogative.

/ ہے؟ شہر خوبصورت لاہور/

In the above sentence /شہر ہے/ is stressed which makes it sound like a question.

In Urdu interrogative information can be contained in words like /کیا، کیوں، کیسے، کب، کہاں/ and in case words containing interrogative content are missing, then questioning tone can be expressed by stressing certain other words in a sentence as shown in the example above.

3. EXPERIMENTAL ANALYSIS

In order to study the intonation patterns in Urdu, acoustic analysis of recorded sentences was performed.

3.1. Data samples

The scope of the analysis was limited to simple declarative and interrogative sentence with minimum or no stops. A single sample sentence was used with four different variations. The data samples include a declarative and an interrogative sentence with two different stresses. Following is the data set that was recorded randomly.

Declarative 1: /ʃæla ∂nar layi hæ/

/ شہلہ انار لائی ہے۔ /

Declarative 2: /ʃæla ∂nar layi hæ/

/ شہلہ انار لائی ہے۔ /

Interrogative 1: /ʃæla ∂nar layi hæ/

/ شہلہ انار لائی ہے؟ /

Interrogative 2: /ʃæla ∂nar layi hæ/

/ شہلہ انار لائی ہے؟ /

3.2 Speakers

Recordings of six speakers were carried out including three male and three female speakers. These speakers were asked to repeat each sample sentence thrice that was block randomized. All the speakers had good Urdu speaking abilities and all of them reported Urdu as their native language. Information regarding speakers is given in Table 1.

Table 1 Speaker Information

Speaker	Age	Sex	Native Language
1	21	F	Urdu
2	20	F	Urdu
3	23	F	Urdu
4	22	M	Urdu
5	22	M	Urdu
6	23	M	Urdu

3.3. Methodology

The recordings of data for all six speakers were done using Hi fidelity (Hi-Fi) Microphone, a Teac Integrated Stereo Amplifier and two high quality speakers with 8 ohms impedance. During the recordings a constant distance from the microphone element and the speaker's mouth was maintained. It is possible to have amplitude fluctuations in some cases due to effects from speakers turning their heads away from a microphone while recording and human error. The recordings were all done in the recording room of **C**enter for **R**esearch in **U**rdu **L**anguage **P**rocessing (CRULP).

All the six speakers were given the block-randomized samples with required stresses and intonation specified for each sample. Recordings of each speaker were done individually and identical environment was maintained for every speaker.

The data recordings were then analyzed using Praat acoustically and phonologically. Praat is a tool for recording, analyzing, manipulating and synthesizing speech samples. The signals were modified by, inserting and deleting pitch points. Pitch points that occur due to the noise in the signal can be removed. This can be done by deleting the pitch point and perceptually testing the sample, if the naturalness of the speech remains unaffected, then the pitch point is redundant and can be removed. Figure 1 displays a screen shot of a Praat file where pitch points can be added or deleted according to the requirement.

Figure 1 Praat file showing the pitch of a sound sample

Acoustically f0 transitions, values for low and high pitch points were recorded. The pitch point having a higher value with respect to the other pitch points in the manipulated sample is the high pitch point marked as 'H'. Similarly low pitch points are marked as 'L'.F0 transition between two pitch points was calculated by subtracting the frequency of the respective pitch points. The duration of f0 transitions between two pitch points was calculated by subtracting the time duration in seconds of the respective pitch points. The f0 transitions and durations are can be seen in Appendix A.

Declination is the occurrence of two low pitch points at the end of the speech sample. Usually declination is observed in declarative sentences and the

last low pitch point makes the speech sound more natural. Therefore declination was also recorded. Finally, the acoustic analysis was completed by calculating the extent of the f0 transition by the formula given in equation (1).

Extent = F0 Transition / F0 Duration (1)

Phonologically, tone and sequence of intonation was observed. Then low and high peaks were mapped onto the syllables of each word of the sentence and a generalized syllable pattern map was derived.

4. RESULTS

4.1. Pattern of Fundamental Frequency

The data recorded show that the trend for the male speakers for the first declarative sentence with stress on /ʃæla/ is LHL 78% of the time while LHLL pattern was observed 22% of the time. On the other hand female speakers generally say the first declarative sentence observing the LHLL sequence 63% of the time and LHL sequence 25% of the time. HL pattern was also found amongst female speakers and that was 12% of the time. Hence LHL pattern occurs with the highest percentage, 52%, while LHLL pattern was observed for 43% of the speakers irrespective of the gender differences.

The sequence for the second declarative sentence with stress on /ə̂nar/ is LHL for all the recordings of male speakers. Similarly LHL trend was observed for 89% of the female speakers and only for 11% of the time LHLL pattern was observed. Therefore on average LHL pattern was observed with the highest percentage of 95% for the second declarative sentence for all the 6 speakers.

The data recorded shows that the trend for the first interrogative sentence with stress on /layi/ is 86% for LHLH and 14% for HLH, for male speakers. 56% of the time LHLH trend was observed amongst female speakers for the first declarative sentence while 44% of the time HLH pattern was observed. Hence 71% of the time LHLH pattern was observed and 29% of the time HLH was observed for the first interrogative sentence for all the speakers.

For the second interrogative sentence with stress on /ə̂nar/, 75% of the time LHL pattern was observed and 25% of the time LHLH sequence was observed amongst male speakers. Amongst female speakers, LHL pattern was observed 50% of the time, HLH pattern was observed 38% of the time and HLHL sequence was observed 12% of the time. Therefore LHL pattern is observed with the highest percentage, i.e., 63% for all the 6 speakers for the second interrogative sentence.

4.2. F0 Transitions and Duration

It is evident from the data given in Appendix A.1 that LHL peaks for male speakers for declarative sentences on average map at 185 Hz with duration 1.03 sec, 220 Hz with duration 1.32 sec and 140 Hz with duration 1.74 sec respectively, whereas the LHL peaks for female speakers for declarative sentences on average map at around 230 Hz with duration 0.99 sec, 286 Hz with duration 1.2 sec and 198 Hz with duration 1.44 sec respectively. Declination was observed in the first declarative sentence for male and female speakers and on average the rate (extent of frequency/extent of duration) of declination is 35.8 Hz/sec for male speakers and 51.5 Hz/sec for female speakers. Comparison of the f0 transition and duration for the declarative sentences is illustrated in Figure 1 and Figure 2.

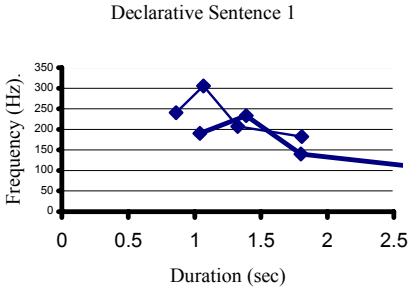

Figure 2 Comparison of F0 transitions of declarative sentence in males and females. Male frequency pattern is bold for clarity.

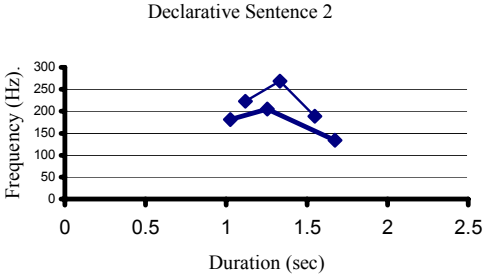

Figure 3 Comparison of F0 transitions of declarative sentence in males and females. Male frequency pattern is bold for clarity.

It is clear from the data given in Appendix A that on average the LHLH peaks for the first interrogative sentence for male speakers map at 150 Hz with duration 1.002 sec, 182 Hz with duration 1.18 sec, 137 Hz with duration 1.56 sec and 215 Hz with duration 1.8 sec respectively whereas on average the LHLH peaks for the first interrogative sentence for female speakers map at 260 Hz with duration 0.99 sec, 260 Hz with duration 1.2 sec, 200 Hz with duration 1.66 sec and 411 Hz with duration 2.02 sec respectively. Similarly on average the LHL peaks for the second interrogative sentence for male speakers map at 146 Hz with duration 1.3 sec, 234 Hz with duration 1.48 sec, 186 Hz with duration 1.79 sec respectively whereas on average the LHL peaks for the second interrogative sentence for female speakers map at 239 Hz with duration 1.213 sec, 217 Hz with duration 1.45 sec and 426 Hz with duration 1.75 sec respectively. Comparison of the f0 transitions and duration in interrogative sentences of males and females is illustrated in Figure 3 and Figure 4. Male Frequency pattern is bold for clarity.

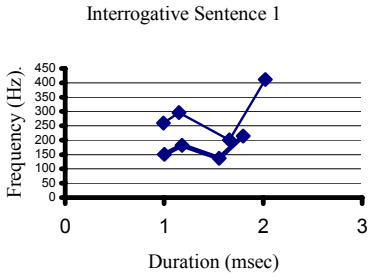

Figure 4 Comparison of F0 transitions of interrogative sentence in males and females. Male frequency pattern is bold for clarity.

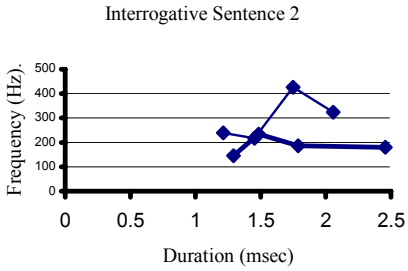

Figure 5 Comparison of F0 transitions of interrogative sentences in males and females. Male frequency pattern is bold for clarity.

5. DISCUSSION

5.1. Syllable Pattern Map

The general trend observed for declarative and interrogative sentences is given in Table 2.

Table 2 General Syllable Pattern Map of Declarative and Interrogative Sentences

Sentence	General F0 Pitch Sequence	General Syllable Pattern Map
Declarative 1	LHL	L L H
Declarative 2	LHL	L L H L
Interrogative 1	LHLH	H L H L L H
Interrogative 2	LHL	L L H L

Detailed analysis of declarative sentences yielded the fact that generally declarative sentences follow the LHL pattern where the first low pitch point is mapped on to the first syllable of the first word. Also in all the recordings of the 6 speakers, high f0 peak occurs at the stressed word /ʃæla/ and /ðnar/ for the first and second declarative sentences respectively. Further analysis showed that the high pitch contour lies precisely at the syllable containing a vowel in the stressed word. For example Table 2 shows that the high pitch point of the fundamental frequency generally occurs at the stressed syllable /ʃæ.la/ and /ðn.ar/ for the two declarative sentences. The final low peak of the LHL pattern is mapped onto the vowel-containing syllable of the last word. It was observed that the last low peak was always lower then the first low peak. In some cases LHLL pattern was also achieved and removing the last low peak to some extent affected the naturalness of speech. In that case the last low peak is declination, which is the property of the declarative sentences.

Incase of interrogative sentences, since there is no interrogative word so the syllable containing the vowel of the stressed word is always in pitch. Also in the interrogative sentences the first low peak is always mapped to the first syllable of the first word. The second high peak is at the syllable containing the vowel, of the first word. However incase of second interrogative sentence, the second syllable of the first word does not contain a high pitch point since it is followed by a stressed word and the high peak is shifted onto the vowel-containing syllable of the stressed word. In the case of the first interrogative sentence, the next high peak again lies on the syllable containing the vowel of the stressed word and the final high peak is mapped onto the last word since the interrogative word is missing and it is the last word with high pitch, which makes the sentence sound like a question. The second interrogative sentence has a pattern identical to the declarative sentence but it sounds like a question due to a different mapping of low and high pitch points on the syllables, i.e., due to the high frequency of the vowel-containing syllable of the stressed word. Furthermore the last low peak again maps to the vowel-containing syllable of the last word but it is of higher frequency then the first low peak that makes the sentence to be perceived like a question.

Analysis also revealed that the intonation pattern remains unaffected by gender differences. However the pitch and duration may differ.

5.2. Gender Differences in f0 Transitions and Duration

It is evident from the results deduced that the fundamental frequency of male speakers is on average 50 Hz lower then the female speakers for declarative sentences while it is almost 100 Hz lower in case of interrogative sentences. The duration of f0 for male speakers is a few sec less then the female speakers in both declarative and interrogative sentences.

6. CONCLUSION

In conclusion, it can be said that male and female speakers on average display LHL pattern of intonation for declarative sentences. Also LHLH pattern

of intonation was observed amongst the 6 speakers where the interrogative information is contained in a word lying at the sentence end and LHL sequence was observed when the interrogative information lies in the sentence middle. Male speakers have lower f0 and lesser duration then the female speakers but their intonation pattern is indifferent. It was also concluded that the vowel-containing syllable of the stressed word in the sentence, always has a high frequency and thus contains a high pitch point.

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APPENDIX A

Average F0 Transitions and Durations for Declarative

				Declarative 1				
	1st transition	*2nd transition*	*3rd transition*	*4th transition*	*Duration 1*	*Duration 2*	*Duration 3*	*Duration 4*
mspk1-average	157.933	237.167	136.567	112.35	1.35164	1.99317	2.16538	2.57178
mspk2-average	177.4	204.767	143.467		0.54548	0.75378	1.45307	
mspk3-average	236.5	258.133	140.033		1.21846	1.41569	1.78078	
fspk1-average	247.7	311.267	220.667	198.35	0.77778	1.01563	1.18981	1.70278
fspk2-average	272.7	358.3	207.25	169.95	1.16889	1.29889	1.54389	2.04889
fspk3-average	214.6	264.7	193.167	174.6	0.71032	0.96516	1.31607	1.53048
				Declarative 2				
	1st transition	*2nd transition*	*3rd transition*	*4th transition*	*Duration 1*	*Duration 2*	*Duration 3*	*Duration 4*
mspk1-average	129.2667	153.033	117.867		1.3121	1.59328	1.79127	
mspk2-average	159.493	198.267	137.933		0.75019	0.97283	1.36283	
mspk3-average	186.467	182.067	167.533		0.92595	1.36262	1.64928	
fspk1-average	243.767	301.5	210.2	189.7	0.8873	0.98464	1.17407	1.733447
fspk2-average	225.4	260.767	177.233			1.24424	1.55093	1.7076
fspk3-average	198.533	244.067	177.9		1.22201	1.4642	1.76583	
				Interrogative 1				
	1st transition	*2nd transition*	*3rd transition*	*4th transition*	*Duration 1*	*Duration 2*	*Duration 3*	*Duration 4*
mspk1-average	138.8	166.6	116.4	172.733	1.38097	1.63527	2.15527	2.40308
mspk2-average	162.9	198.8	154.5	230.667	0.62232	0.84492	1.17565	1.38792
mspk3-average		177.2	150.2	292.6		0.8335	0.9035	1.2235
fspk1-average	265.367	359.467	226.8	534	1.0783	1.24284	1.80234	2.05724
fspk2-average	250.65	297.333	195.233	409.8	1.3629	1.50239	1.71165	2.14239
fspk3-average		230.433	180.867	290.233		0.70977	1.46326	1.86646
				Interrogative 2				
	1st transition	*2nd transition*	*3rd transition*	*4th transition*	*Duration 1*	*Duration 2*	*Duration 3*	*Duration 4*
mspk1-average	135.133	177.8	126.833	180.2	1.5062	1.65232	1.89232	2.45626
mspk2-average	150.667	241.3	192.067			0.98714	1.13782	1.5736
mspk3-average		177.2	150.2	292.6		0.8335	0.9035	1.2235
fspk1-average	269.3	455.567	469.5	403.9	1.61566	1.78901	2.06568	2.48464
fspk2-average		296.433	194.967	384.867		1.06542	1.33109	1.83776
fspk3-average		189.8	269.95	258.35		1.27755	1.46763	1.94427

APPENDIX B

B.1 Raw Data for Declarative Sentences

DECLARATIVE SENTENCES

Male Speakers

Declarative 1

	1st trans	2nd trans	3rd trans	4th trans	Duration 1	Duration 2	Duration 3	Duration 4	Sequence
mspk1-1	142.2	182.7	127.3		0.841293	2.562585	2.562585		LHL
mspk1-2	188.7	335.4	150.1	111.8	1.983437	2.073379	2.183379	2.893379	LHLL
mspk1-3	142.9	193.4	132.3	112.9	1.230181	1.343531	1.750181	2.250181	LHLL
mspk2-1	178.6	189.5	131		0.535715	0.800873	1.420873		LHL
mspk2-2	188.2	221	143.9		0.486612	0.724206	1.444206		LHL
mspk2-3	165.4	203.8	155.5		0.614116	0.736266	1.494116		LHL
mspk3-1	231.6	260.6	142.5		1.361882	1.581882	2.059921		LHL
mspk3-2	239.9	264.1	140.3		0.812867	0.994546	1.331773		LHL
mspk3-3	238	249.7	137.3		1.480635	1.670635	1.950635		LHL
Average	*190.6111*	*233.356*	*140.022*	*112.35*	*1.03853*	*1.38754*	*1.79974*	*2.57178*	
Extent	*42.74444*	*93.3333*	*27.6722*		*0.34902*	*0.4122*	*0.77204*		
Rate	*122.4705*	*226.429*	*35.843*						

Declarative 2

	1st trans	2nd trans	3rd trans	4th trans	Duration 1	Duration 2	Duration 3	Duration 4	Sequence
mspk1-1	129.6	145.3	106		1.133798	1.410975	1.670975		LHL
mspk1-2	121.8	159.6	125		1.257511	1.494773	1.677853		LHL
mspk1-3	136.4	154.2	122.6		1.544989	1.874089	2.024989		LHL
mspk2-1	178.6	189.5	131		0.535715	0.800873	1.420873		LHL
mspk2-2	188.2	221	143.9		0.486612	0.724206	1.444206		LHL
mspk2-3	165.4	203.8	155.5		0.614116	0.736266	1.494116		LHL
mspk3-1	231.6	260.6	142.5		1.361882	1.581882	2.059921		LHL
mspk3-2	239.9	264.1	140.3		0.812867	0.994546	1.331773		LHL
mspk3-3	238	249.7	137.3		1.480635	1.670635	1.950635		LHL
Average	*181.056*	*205.311*	*133.789*		*1.02535*	*1.25425*	*1.67504*		
Extent	*24.2556*	*71.5222*			*0.2289*	*0.42079*			
Rate	*105.965*	*169.972*							

Female Speakers

Declarative 1

	1st trans	2nd trans	3rd trans	4th trans	Duration 1	Duration 2	Duration 3	Duration 4	Sequence
fspk1-1	234.6	335.8	222.1	192.6	0.773776	0.923776	1.093776	1.893776	LHLL
fspk1-2	260.8	297.5	226.2	204.1	0.781791	0.909263	1.081791	1.511791	LHLL
fspk1-3		300.5	213.7			1.213855	1.393855		HL
fspk2-1	243.6	282.3	200.1	309	1.294649	1.484649	1.644649	2.224649	LHLH
fspk2-2	270.4	362	210.8	170.4	1.623401	1.763401	1.983401	2.603401	LHLL
fspk2-3	275	354.6	203.7	169.5	0.714376	0.834376	1.104376	1.494376	LHLL
fspk3-1	202	249.6	190.6		1.156167	1.362642	1.732642		LHL
fspk3-2	207.8	266.1	191.2		0.56431	0.862347	1.245092		LHL
fspk3-3	234	278.4	197.7	174.6	0.410476	0.670476	0.970476	1.530476	LHLL
Average	*240.657*	*305.563*	*207*	*182.24*	*0.86061*	*1.06752*	*1.32568*	*1.80676*	
Extent	*64.9054*	*98.5625*	*24.76*		*0.2069*	*0.25816*	*0.48109*		
Rate	*313.699*	*381.79*	*51.4667*						

Declarative 2

	1st trans	2nd trans	3rd trans	4th trans	Duration 1	Duration 2	Duration 3	Duration 4	Sequence
fspk1-1	256.2	333.7	205.3		0.857111	0.934921	1.124921		LHL
fspk1-2	241.9	290.6	221.3		1.110193	1.194399	1.342693		LHL
fspk1-3	233.2	280.2	204		0.694603	0.824603	1.054603		LHL
fspk2-1	205.9	256.3	178.3		1.433537	1.603537	1.793537		LHL
fspk2-2	227.6	261.7	176.9		1.39422	1.774286	1.954286		LHL
fspk2-3	242.7	264.3	176.5		0.904977	1.274977	1.374977		LHL
fspk3-1	207	259.4	194.1		1.574887	1.704887	1.859773		LHL
fspk3-2	198.1	234.8	166.7		1.226288	1.63288	1.96288		LHL
fspk3-3	190.5	238	172.9		0.864841	1.054841	1.474841		LHL
Average	*222.567*	*268.778*	*188.4444*		*1.11785*	*1.33326*	*1.5491679*		
Extent	*46.2111*	*80.3333*			*0.21541*	*0.21591*			
Rate	*214.528*	*372.071*							

B.2 Raw Data for Interrogative Sentences

INTERROGATIVE SENTENCES

Male Speakers

Interrogative 1

	1st trans	2nd trans	3rd trans	4th trans	Duration 1	Duration 2	Duration 3	Duration 4	Sequence
mspk1-1	144.6	170.9	117.4	160	1.470408	1.650408	2.310408	2.530408	LHLH
mspk1-2	130.5	162	112.6	178.4	1.351825	1.611825	2.261825	2.545464	LHLH
mspk1-3	141.3	166.9	119.2	179.8	1.320673	1.643571	1.893571	2.133357	LHLH
mspk2-1	170.1	201	155.6	222.2	0.273265	0.51108	0.963265	1.113265	LHLH
mspk2-2	165.9	199.2	154.8	251	1.193583	1.403583	1.593583	1.866002	LHLH
mspk2-3	152.7	196.2	153.1	218.8	0.400102	0.620102	0.970102	1.184482	LHLH
mspk3-1	145.1	306.7	268.7		0.862234	1.112234	1.332234		LHL
mspk3-2		177.2	150.2	292.6		0.833503	0.903503	1.223503	HLH
mspk3-3		190.9	148.3	300.7		1.044625	1.164615	1.464615	HLH
Average	150.85	181.9143	137.5571	214.6857	1.001643	1.18201	1.556608	1.799497	
Extent	31.06429	44.35714	77.12857		0.180368	0.374598	0.242889		
Rate	172.2276	118.4127	317.5464						

Interrogative 2

	1st trans	2nd trans	3rd trans	4th trans	Duration 1	Duration 2	Duration 3	Duration 4	Sequence
mspk1-1	129.8	181.4	133.4		0.867504	1.014444	1.344444		LHL
mspk1-2	141.8	180.2	127.4	183.3	1.779682	1.901111	2.101111	2.361111	LHLH
mspk1-3	133.8	171.8	119.7	177.1	1.871406	2.041406	2.231406	2.551406	LHLH
mspk2-1	146.9	259.2	199.3		1.002076	1.202085	1.612075		LHL
mspk2-2	158.2	233.8	198.1		0.943957	1.033957	1.503957		LHL
mspk2-3	146.9	230.9	178.8		1.015386	1.177432	1.604773		LHL
mspk3-1	149.3	277.7	229.2		1.253866	1.573866	1.783866		LHL
mspk3-2	152.2	275.3	232.7		1.881474	2.161474	2.441474		LHL
mspk3-3	153.6	294.7	252.9		1.002018	1.262018	1.472018		LHL
Average	***145.8333***	***233.8889***	***185.7222***	***180.2***	***1.290819***	***1.48531***	***1.788347***	***2.456259***	
Extent	***88.05556***	***48.16667***	***5.52222***		***0.19449***	***0.30304***	***0.66791***		
Rate	***452.7474***	***158.9466***	***8.267896***						

Female Speakers

Interrogative 1

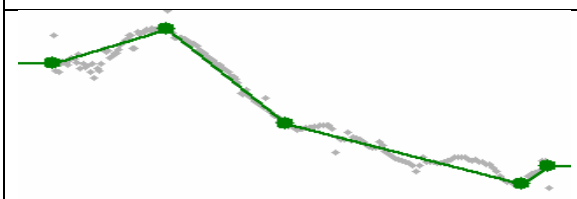
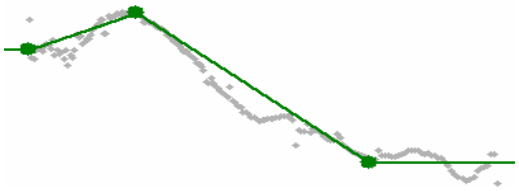
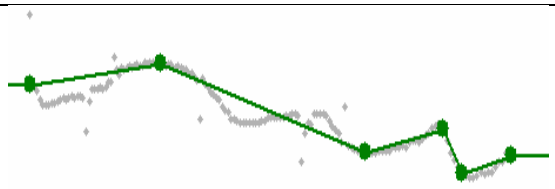
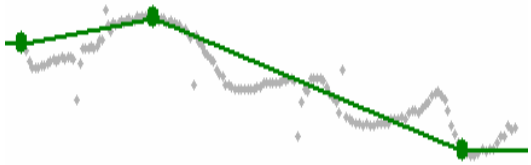
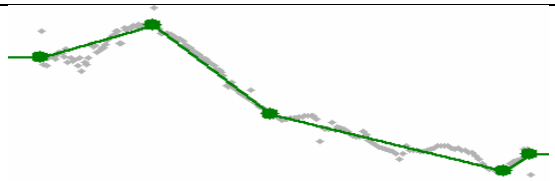
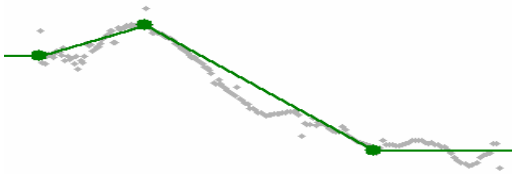
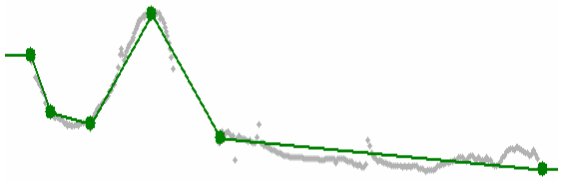
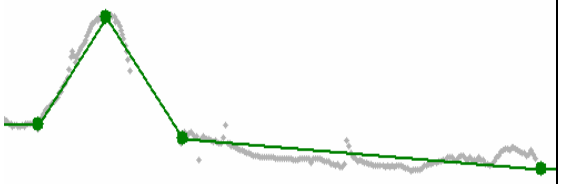
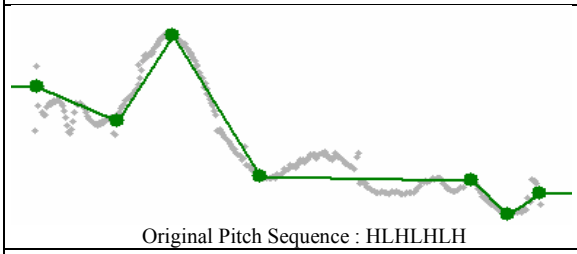
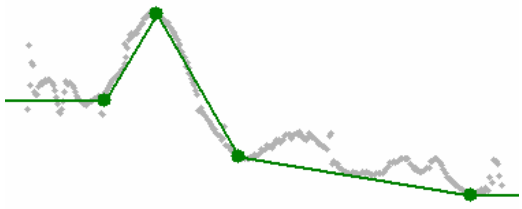
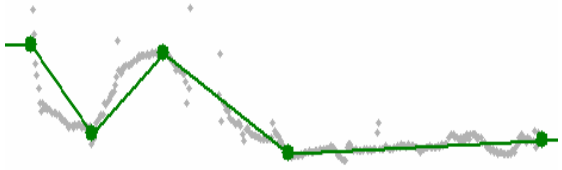
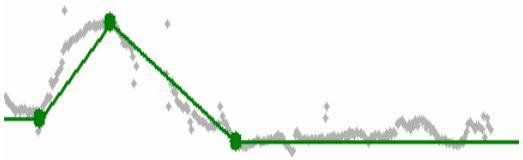
	1st tras	2nd trans	3rd trans	4th trans	Duration 1	Duration 2	Duration 3	Duration 4	Sequence
fspk1-1	265.5	363.3	218.4	541.1	1.060385	1.200385	1.728366	2.080385	LHLH
fspk1-2	264.5	350.7	233.8	547	0.633687	0.837333	1.46051	1.64051	LHLH
fspk1-3	266.1	364.4	228.2	513.9	1.540816	1.690816	2.218146	2.450816	LHLH
fspk2-1	264	293.4	200.6	371.3	0.863821	1.023821	1.251599	1.703821	LHLH
fspk2-2		280.4	198	403.9		1.171372	1.391372	1.811372	HLH
fspk2-3	237.3	318.2	187.1	454.2	0.861984	2.311984	2.491984	2.911984	LHLH
fspk3-1		227	179.7	296.5		0.801168	1.644415	2.051168	HLH
fspk3-2		225.9	176.6	295.9		0.503288	1.253288	1.696139	HLH
fspk3-3		238.4	186.3	278.3		0.824842	1.492086	1.852086	HLH
Average	***259.48***	***295.7444***	***200.9667***	***411.3444***	***0.99214***	***1.151668***	***1.659085***	***2.022031***	
Extent	***36.26444***	***94.77778***	***210.3778***		***0.15953***	***0.507417***	***0.362946***		
Rate	***227.322***	***186.785***	***579.639***						

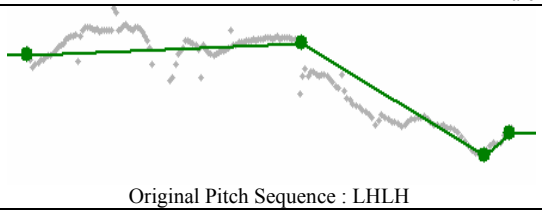
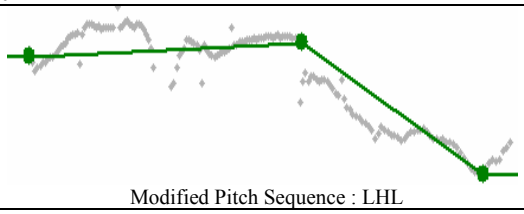
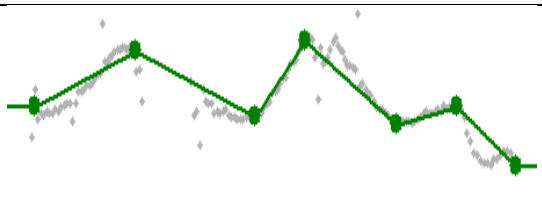
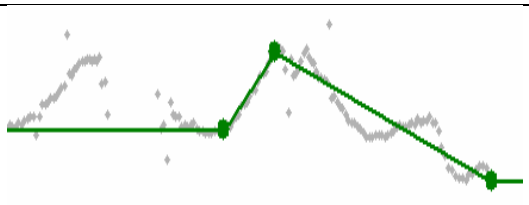
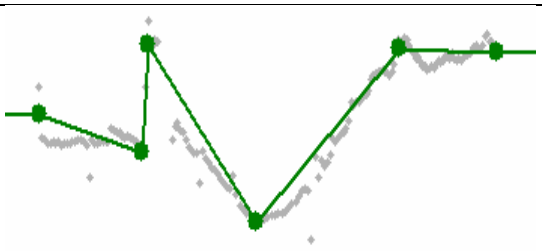
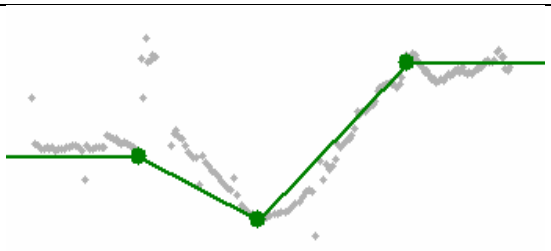
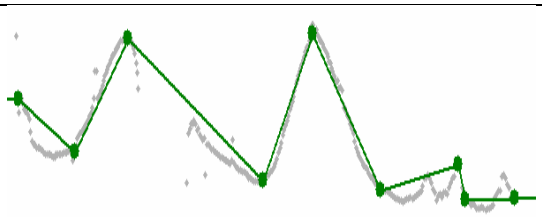
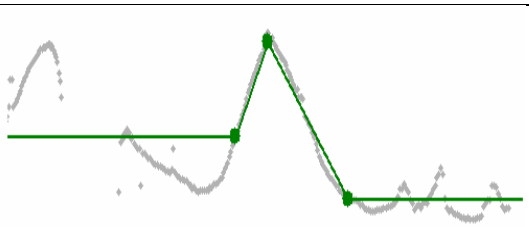
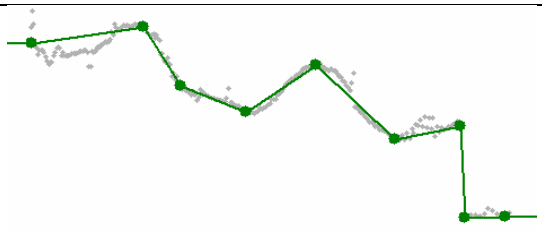
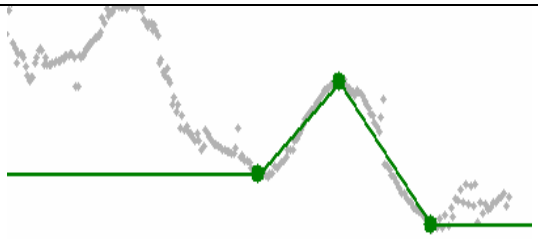
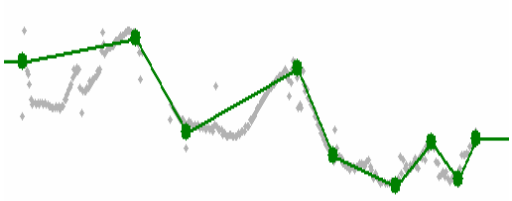
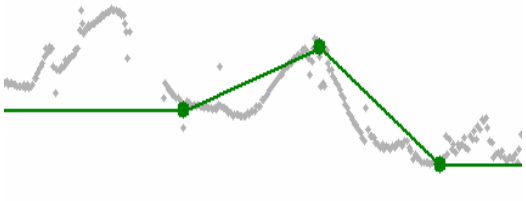
Interrogative 2

	1st trans	2nd trans	3rd trans	4th trans	Duration 1	Duration 2	Duration 3	Duration 4	Sequence
fspk1-1		273.3	588.7	424.8		1.868878	2.010556	2.240556	LHL
fspk1-2	268.3	231	574.8	403.9	1.654637	1.884637	2.064637	2.484637	HLHL
fspk1-3		266.3	547	408.9		1.323476	1.471848	1.891848	LHL
fspk2-1	316.8	186.5	382.5		0.880714	1.130714	1.730714		HLH
fspk2-2	273.3	208	355		1.243572	1.48059	1.75059		HLH
fspk2-3	299.2	190.4	417.1		1.071961	1.381961	2.031961		HLH
fspk3-1		185.3	267	259.7		1.452868	1.642868	2.132868	LHL
fspk3-2		194.3	272.9	257		1.102239	1.292392	1.755665	LHL
fspk3-3		243.4	184.4	282.8		1.164172	1.884172	2.204172	HLH
Average	***238.5818***	***216.8875***	***425.625***	***324.4286***	***1.212721***	***1.45317***	***1.749446***	***2.056301***	
Extent	***21.69432***	***208.7375***	***101.1964***		***0.240449***	***0.296275***	***0.306855***		
Rate	***90.224***	***704.539***	***329.786***						

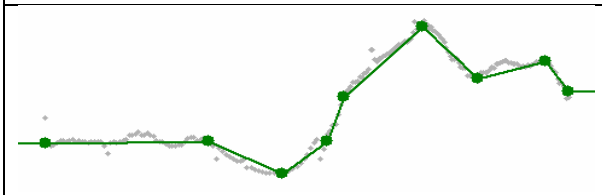
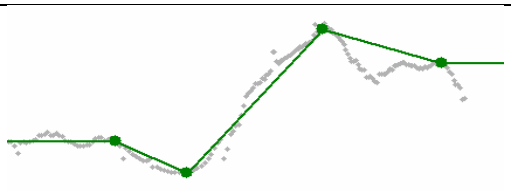
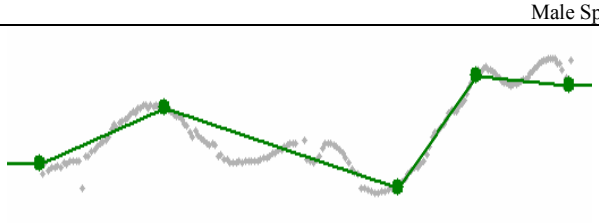
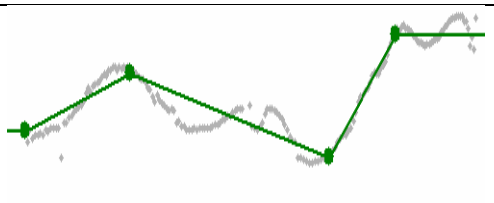
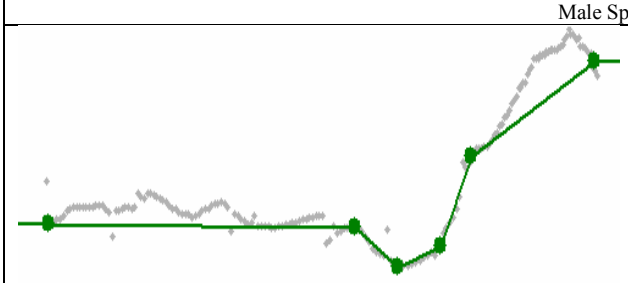
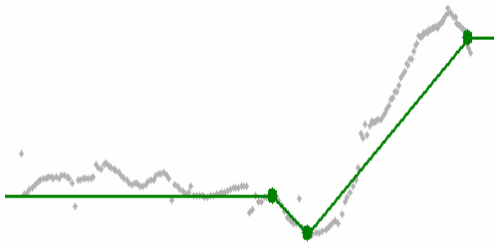
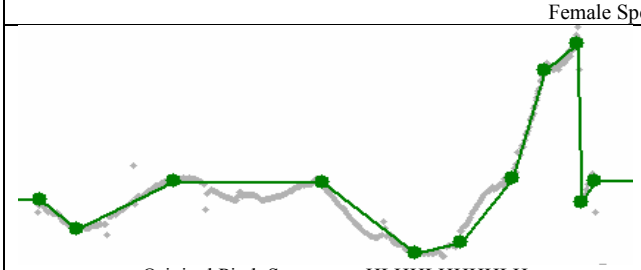
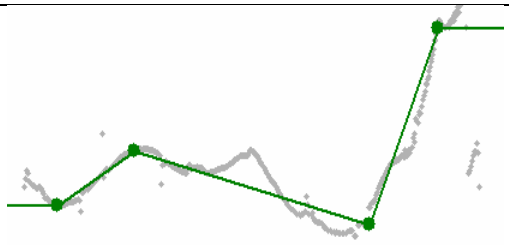
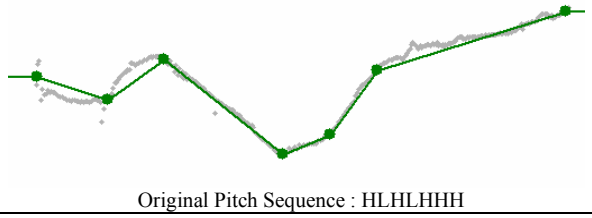
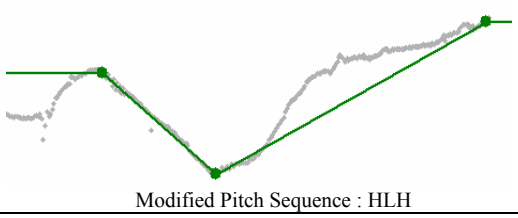
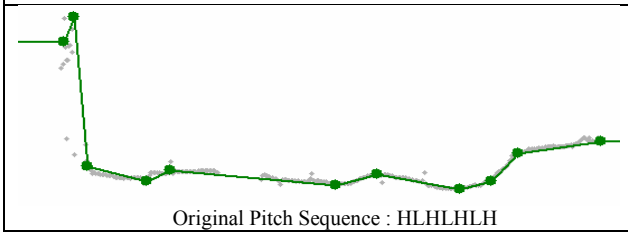
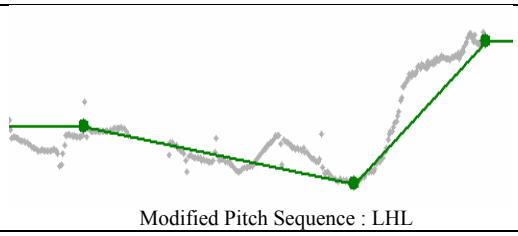
Appendix C

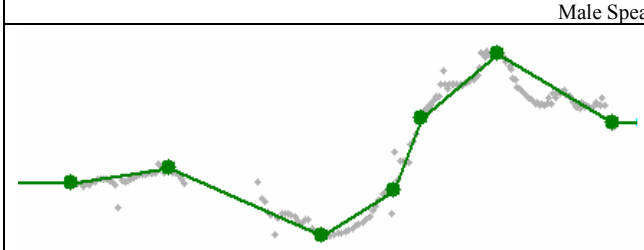
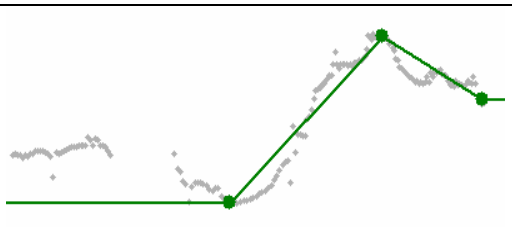
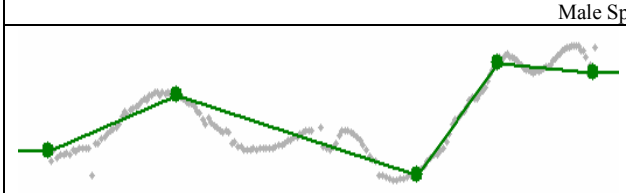
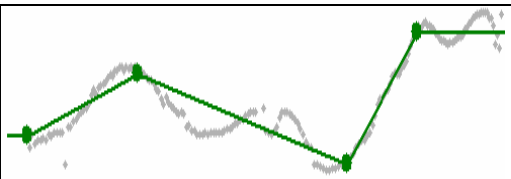
C.1 Snapshots of Declarative Sentences

DECLARATIVE SENTENCES	
Declarative 1	شہلہ انار لائی ہے ۔
Original Samples	Modified Samples
Male Speaker 1	
 Original Pitch Sequence : LHLLH	 Modified Pitch Sequence : LHL
Male Speaker 2	
 Original Pitch Sequence : LHLHLH	 Modified Pitch Sequence : LHL
Male Speaker 3	
 Original Pitch Sequence : LHLLH	 Modified Pitch Sequence : LHL
Female Speaker 1	
 Original Pitch Sequence : HLLHLL	 Modified Pitch Sequence : LHLL
Female Speaker 2	
 Original Pitch Sequence : HLHLHLH	 Modified Pitch Sequence : LHLL
Female Speaker 3	
 Original Pitch Sequence : HLHLHLH	 Modified Pitch Sequence : LHL

Declarative 2	شہلہ انار لائی ہے ۔
Original Samples	Modified Samples
Male Speaker 1	
 Original Pitch Sequence : LHLH	 Modified Pitch Sequence : LHL
Male Speaker 2	
 Original Pitch Sequence : LHLHLHL	 Modified Pitch Sequence : LHL
Male Speaker 3	
 Original Pitch Sequence : HLHLHL	 Modified Pitch Sequence : HLH
Female Speaker 1	
 Original Pitch Sequence : HLHLHLHLH	 Modified Pitch Sequence : LHL
Female Speaker 2	
 Original Pitch Sequence : LHLLHLHLH	 Modified Pitch Sequence : LHL
Female Speaker 3	
 Original Pitch Sequence : LHLHLLHLH	 Modified Pitch Sequence : LHL

C.2 Snapshots of Interrogative Sentences

INTERROGATIVE SENTENCES	
Interrogative 1	شہلہ انار لائی ہے؟
Original Samples	Modified Samples
Male Speaker 1	
 Original Pitch Sequence : LHLHHHLHL	 Modified Pitch Sequence : HLHL
Male Speaker 2	
 Original Pitch Sequence : LHLHL	 Modified Pitch Sequence : LHLH
Male Speaker 3	
 Original Pitch Sequence : LHLLHH	 Modified Pitch Sequence : HLH
Female Speaker 1	
 Original Pitch Sequence : HLHHLHHHHLH	 Modified Pitch Sequence : LHLH
Female Speaker 2	
 Original Pitch Sequence : HLHLHHH	 Modified Pitch Sequence : HLH
Female Speaker 3	
 Original Pitch Sequence : HLHLHLH	 Modified Pitch Sequence : LHL

Interrogative 2	شہلہ انار لائی ہے؟
Original Samples	Modified Samples
Male Speaker 1	
 Original Pitch Sequence : LHLHHHL	 Modified Pitch Sequence : LHL
Male Speaker 2	
 Original Pitch Sequence : LHLHL	 Modified Pitch Sequence : LHLH
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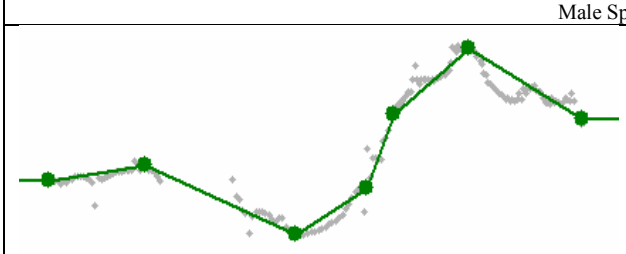
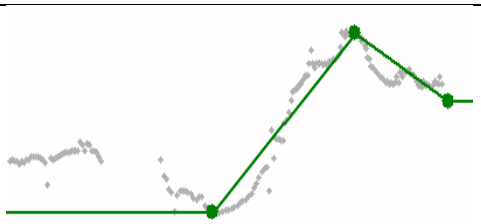
 Original Pitch Sequence : LHLHHHL	 Modified Pitch Sequence : HLH
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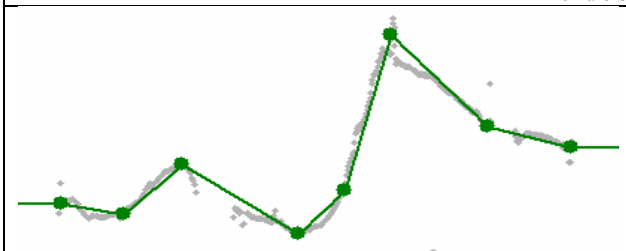
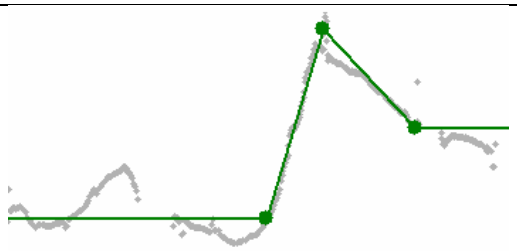
 Original Pitch Sequence : HLHLHHLL	 Modified Pitch Sequence : LHL
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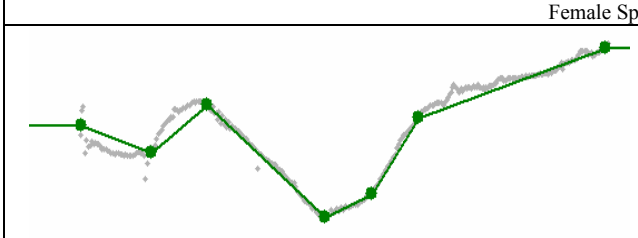
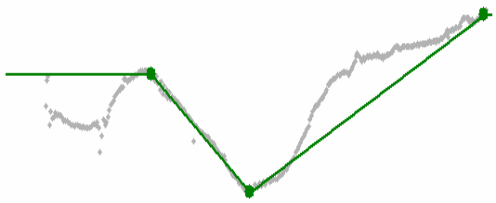
 Original Pitch Sequence : HLHLHHH	 Modified Pitch Sequence : HLH
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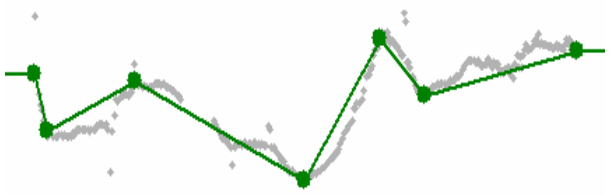
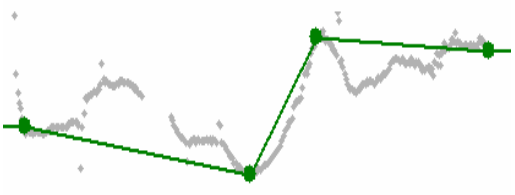
 Original Pitch Sequence : HLHLHLH	 Modified Pitch Sequence : HLHL