EFFECT OF FREQUENCY ALTERED FEEDBACK AND DELAYED AUDITORY FEEDBACK ON LEXICAL TONES OF MIZO LANGUAGE

Zothansiami

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ALL INDIA INSTITUTE OF SPEECH AND HEARING

MANASAGANGOTRI, MYSURU- 570006

SEPTEMBER 2023

CERTIFICATE

This is to certify that this dissertation entitled **"Effect of Frequency Altered Feedback and Delayed Auditory Feedback on Lexical Tones of Mizo Language"** is a bonafide work submitted in part fulfillment for the degree of Master of Science (Speech-Language Pathology) of the student Registration Number: P01II21S0045. This has been carried out under the guidance of a faculty of this institute andhas not been submitted earlier to any other University for an award of any other diploma or degree.

Mysuru
September, 2023

Dr. M. Pushpavathi
Director
All India Institute of Speech and Hearing
Manasagangothri
Mysuru- 570006

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Mysuru
September, 2023

Dr. Santosh M
Guide
Professor of Speech Sciences
Department of Speech Language Sciences
All India Institute of
Speech and Hearing,
Manasagangothri, Mysuru- 570006

DECLARATION

This is to certify that this dissertation entitled **"Effect of Frequency Altered Feedback and Delayed Auditory Feedback on Lexical Tones of Mizo Language"** is the result of my own study under the guidance of Dr. M. Santosh, Professor in Speech Sciences, Department of Speech-Language Sciences, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier to any other University for award of any other diploma or degree.

Mysuru
September, 2023

Registration number:
P01II21S0045

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Dedicated to my father
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CHAPTER I

INTRODUCTION

1.1 Tonal language

Pike (1964) defined tonal languages having significant, contrastive but relative pitch on each syllable. In tonal languages changing the pitch of the word alters the meaning of the word. Tone languages are spoken all over the world, and their phonological structure differs widely (Yip, 2002). Pitch is also significant in English, but the semantic differential applies to the phrase as a whole. For this reason, English is not called as a tonal language. The contrastive, lexical units of sounds are phonemes or in tonal analysis are referred to as tonemes. In tone languages, the pitch contrast or significant pitch differences entail one pitch being kept different from another pitch in the immediate context. Two level pitches may contrast by one of them being relatively higher than the other or a rising pitch contrast with a falling pitch.

1.2 Tone system

Tone languages have been divided into two types; Contour tone system and Register tone system (Pike, 1964). Contrary to contour tones, register tones have a strong connection to the African tone system, whereas the contour system has a connection to Asian languages like Chinese. African languages are known for having a register tone system, which is a level tone. It is considered to be level and to be retaining some degree of stability. Compared to contour tone system, it is shorter in duration.

Contour tone, is a feature of Asian languages. They are not stable since they are analyzed as gliding from one pitch level to another. Compared to register tone system, it is longer in duration. Contextual phonological interpretations of contour tones might vary more than those of level tones. African languages' contour tones are typically thought of as composite, in contrast to Chinese languages where they are viewed as unitary components.

Four distinct tones exist in Mandarin Chinese with Tone 1 having high level pitch, Tone 2- high rising pitch, Tone 3- low dipping pitch and Tone 4 having high falling pitch. The same segmental context can have multiple interpretations depending on the tone (Jongman et al., 2005.). Mizo has four distinct tones namely High, Low, Rising and Falling (Gogoi et al., 2020). Any additional tonal variations in Mizo language that occurs are the result of individual pitch differences due to phonological, morphological and syntactic alterations (Fanai, 2015.). Some tone languages do not exhibit tone sandhi but it occurs in some tone languages, to the extent that the inherent tonal specification of the individual morphemes differs significantly from the phonological specification in a given utterance (Yip, 2002).

1.3 Language background

Manipuri, Mizo and Naga languages, which belong to the Tibeto- Burman subgroup of the Tibeto- Chinese family are spoken in the North Eastern areas of India. Mizo is an ethnolinguistic term which stands for both the language and tribe. Mizo is reportedly also spoken in some areas of Bangladesh and Myanmar. The most widely spoken dialect in Mizoram is the Duhlian commonly referred to as Lusei. Traditional Lusei was mixed with remnants of Mara, Fanai and Chhangte dialects and this mingling resulted in the birth of Mizo. Tones can vary in pitch because of the intonation contour, stress and sandhi. For tonal languages like Mizo, tones and intonation are the acoustic cues to distinguish, just like every language has its own distinctive features. High (H), Low (L), Rising (R) and Falling (F) are the four tones reported. Chhangte (2021) described the tone as High (level), Falling (high to low), Rising and allophonic Mid-level and Mid-to-Low falling tones. The fundamental frequency contour within a vowel serves as the main perceptual cues for differentiating across tone categories (House, 1996). F0 has a distinct function in tonal languages than it does in other languages. The contrastive and lexically relevant tonal melodies may be illustrated in the following examples:

a. (i) lei – H - slanting

(ii) lei –R - to buy

(iii) lei – L - bridge

b. (i) pa – F - father

(ii) pa – L – male

(iii) pa – R - mushroom

Meaning can be altered by applying different tonal specifications to the same word. Following example will demonstrate homophony and homophonous

a. (i) mu = High tone - ‘sleep’

(ii) mu = High tone - ‘eagle’

b. (i) tui = High tone - ‘be tasty’

(ii) tui = High tone - ‘egg’

c. (i) la = Low tone - ‘take’

(ii) la = Low tone - ‘thread’

d. (i) dai = Low tone - ‘be cool’

(ii) dai = Low tone - ‘dew’

A distinctive feature of the Tibeto Burman language family, voiceless nasal sounds are present in Mizo. Even nasal sounds when coupled with /h/ can become voiceless.

Examples are: Hma - /mha/ - Front, early

Hnai - /nhai/ - Near

1.4 Need of the study

The role of auditory feedback is important in the control of articulation (Houde & Jordan, 2002). According to studies by Jones and Munhall, (2002), changing the auditory feedback can have an impact on speech production. Auditory feedback informs speech motor objectives during development, and it is crucial for sustaining articulation precision during adult speech. Testing the altered feedback for speakers of a tone language tests not only the postural but the role of the auditory feedback for the laryngeal control as well (Jones & Munhall, 2002). Meaning that there is a specific pitch goal in a tone language that the talker should “aim” towards. The fundamental frequency contour within a vowel is the main perceptual signal used to distinguish distinct tone categories, even though tones change in absolute pitch as a result of intonation contour, stress and sandhi. Therefore, fundamental frequency plays a different role in tone languages than it does in languages like English. In tone languages, vocal pitch also plays a greater phonemic role in addition to its direct correlation to postural setting, but this is not the case in English. Jones and Munhall (2002)also mentioned that within 100-150ms of an alteration in the auditory feedback, speakers would modify their pitch as a compensating mechanism.

Stuart et al. (2002) evaluated how a normal speaker’s rate changed when a delay in auditory feedback (both long and shirt) was applied in English. In comparison to no delay or the shorter delays, a measurable two to three times greater number of dysfluencies were observed at 200ms. They found correlation between dysfluencies and high rate of speech.

In another research conducted by Xu and Meng (2010), they found that while there were no appreciable variations between Chinese and Japanese language for DAF, Chinese had a larger pitch change reduction than Japanese did for FAF. In the Frequency Altered Feedback (FAF) and

DAF tests, there were eighteen Chinese and eighteen Japanese participants. With the exception of 14Hz or 50ms, all altered situations revealed speech dysfluency. The participants were given instructions to read the words as they typically would while donning headphones to hear the modified feedback voice. In order to compare the differences between Chinese and Japanese speakers, t-tests were used. Chinese speakers exhibited a greater reduction in pitch variation than do Japanese speakers, with the exception of 0.1 Hz, where there were substantial disparities between the two speaker groups. With respect to DAF there were no notable variations between the two. In both subject groups, the speaking rate was slowed. With the exception of the modulation frequency of 14 Hz, no significant group differences were discovered. For DAF also, the speed of speech was noticeably slowed down in both subject groups. Except for a 50ms delay, no significant group differences were discovered.

Overall, only few investigations are conducted on the effect of Frequency Altered Feedback and Delayed Auditory Feedback on tonal languages. Therefore, studying the Frequency Altered Feedback and Delayed Auditory Feedback in Mizo language will provide us more insight into the sensorimotor processes involved in producing tones and how Auditory feedback affects the generation of tonal languages. This investigation is a replication of a study by Xu and Meng (2010) in which the frequency modulated Auditory Feedback of Chinese and Japanese were adjusted.

1.5 Aim of the study

To investigate the effect of altered feedback conditions including Frequency Altered Feedback (FAF) and Delayed Auditory Feedback (DAF) on Acoustic Parameters of Lexical Tones in Mizo language.

1.6 Objectives of the study

1. To investigate changes in F0 and Duration of Mizo Lexical tones on Frequency Altered Feedback

2. To investigate changes in F0 and Duration of Mizo lexical tones on Delayed Auditory Feedback.

CHAPTER II

REVIEW OF LITERATURE

2.1 Lexical tone

Tone refers to the use of pitch in a language to distinguish lexical or grammatical meaning, or to identify or inflect words. All languages do not use tone as to indicate the words or their inflections, whereas all verbal languages use pitch to convey emphasis, contrast, and other similar elements in order to portray emotions and other paralinguistic information (Zhiming, 2003).

Lexical tones are described as changes in the fundamental frequency contour that differentiate between meaning of the words at the syllable level. The fundamental frequency serves as an indicator of lexical tone which gives specific cues such as mean pitch and pitch contour (Singh & Fu, 2016). However, changes in pitch alone does not determine the lexical tone. There are also secondary cues in identifying tones such as duration, amplitude, voice range and speaker register (Morett, 2019).

Typically tone first manifests in the vowels, but consonant also contribute to tone realization. Lexical tones differ from vowel and consonant in two respects. First, vowels and consonant require segmental alterations, whereas lexical tone involve changes at syllable level. As a result, vowels and consonants are categorized as segmental cues while tone is categorized as supra-segmental cue. Second, spectral analysis can show differences in the acoustic energy of vowels, consonants, and tones (Hombert et al., 1979).

2.2 Acoustic features of tone

2.2.1 Average F0

F0 indicates the number of vibrations of the vocal folds per second. A study Sarmah and Wiltshire (2010) on Mizo tones of average F0, reported 236.80 Hz for falling, 251.71 Hz for high tone, 210.81 for low tone, and 214.54 for rising tone. They have discovered that average F0 of rising, low tones, falling and high tones are statistically same. So, the F0 contour itself is not enough to distinguish tone in Mizo.

Gogoi et al. (2020) did a study and attempted to use acoustic prosodic factors to automatically distinguish between Mizo phonological tones using Support Vector Machine (SVM) and Deep Neural Network (DNN) and six 6 features F0 contour were considered. Speakers were provided meaningful trisyllabic Mizo phrases. The average age of speakers was 22. The results indicated that six F0 features from SVM based classifier offers 73.39% accuracy and DNN based classifier provide an accuracy of 74.11%, which offers an improvement of 0.72% over SVM based classifier.

Lalhminghlui et al. (2019) found the positive correlation between F0 and vowel height. Mizo has 5 vowels while Angami has 6 vowels. Mizo data consisted of 5 long vowels which was produced in isolation with all the four tones existed in Mizo. Whereas Angami data consisted of 6 vowels which was produced in isolation with all the five tones in Angami. The results indicated that, in Mizo in the beginning of the pitch contour (0%) there is a significant effect. High vowels like /u/ and /i/ have higher F0 while low vowels yielded a reverse effect. In cases of low and falling tone vowel height effects are seen at 25% pitch contour. For high tone the vowel effects are maintained throughout the entirety of the pitch contour. Rising tone decreased by 25% of vowel category specific variances in pitch contour. At the end of pitch contour (100%) vowel specific effect is not seen. In Angami, two distinct effects of vowels were apparent, vowels /u/, /i/ and /e/ yielded higher F0 while /a/ and /o/ induced lower F0.

A study conducted on Sumi tone by Teo (2020) in which 38 years and 39 years of female and males were considered. The participants were asked to produce three level tones in the carrier phase. F0 for males were 119 Hz for low, 151 Hz for mid and 185 Hz for high tone, while for females 169 Hz for low tone, 198 Hz for mid and 228 Hz for high tone. Tone contrast in Sumi tone is based on pitch height rather than pitch movement.

2.2.2 Duration

Govind and Sarmah (2012) conducted a study to synthesize tones of Mizo language as durational information is crucial in identifying rising tones in Mizo. Sentences were recorded. The stimuli were produced by single female Mizo speaker. This study demonstrated that durational cues are more crucial in case of rising tone apart from pitch slope information.

Morey et al. (2009) CV, CVC and CVV syllables were considered. CV syllables in rising tones were reported to be shorter in vowel lengths than falling tones [$p=0.02$, $p=<0.05$]. CVV syllables in rising tones were also reported to be shorter than falling tones [$p=0.0282$, $p>0.05$]. CVC syllables in rising tones on the other hand were longer than falling tones [$p=0.04$, $p=0.05$]. Significant durational variations were observed in CVC and CV syllables. CV syllable has duration of 173.73ms for rising tone and 187.75ms for falling tone.

Based on a number of studies on Mandarin tones there are Tone 1 (55-high tone), 4 (51-falling tone) which are shorter than Tone 2 (36-mid rising tone) which is shorter than Tone 3 (214-low dipping tone) (John Marshall Howie, n.d.)

2.2.3 Normalization of F0

The second line of research focus on the fact that listeners can distinguish words produced by various speakers despite the fact that utterances that phonologically similar exhibit acoustic diversity across speakers. In normalization of F0, every 2% of the overall duration, F0 values were extracted automatically. The speaker effects need to be taken out of the F0 contour for speaker independent tone recognition. For gender normalization, z-score is considered to be the most effective method. It uses mean F0 and standard deviation of the population to normalize the data.

NPn= (F0i-x)/SD

Where,

NPn= normalized z-score of a sampling point

X= average F0 of all sampling points

F0i= sampling point

SD= standard deviation of the average of all the sampling points.

CHAPTER III

METHOD

The primary aim of the present study was to investigate the effect of Frequency Altered Feedback and Delayed Auditory Feedback on changes in F0 and Duration parameters of Mizo lexical tones

3.1 Selection of Participants:

Thirty adults in the age range of 18-30 years old were recruited in as participants for the study. The participants were divided into 15 males and 15 females who are proficient in Mizo language and has been residing in Mizoram for 15 years. This study was carried out amongst native speaker of Mizo.

Table 3.1 *Demographic details of the participants*

Participant's name	Age/ Gender	Education
P1	27/M	PG
P2	28/M	PG
P3	18/M	UG
P4	23/M	UG
P5	19/M	UG
P6	19/M	UG

P7	19/M	UG
P8	18/M	UG
P9	18/M	UG
P10	18/M	UG
P11	24/M	UG
P12	30/M	UG
P13	20/M	UG
P14	29/M	PG
P15	25/M	PG
P16	28/F	PG
P17	30/F	PG
P18	29/F	UG
P19	25/F	UG
P20	26/F	UG
P21	26/F	UG
P22	24/F	PG

P23	21/F	UG
P24	23/F	UG
P25	30/F	PG
P26	24/F	UG
P27	22/F	UG
P28	26/F	PG
P29	29/F	UG
P30	24/F	UG

Note: UG- Undergraduates, PG- post graduates, P- participants

3.1.2 Participant's Inclusion Criteria:

Inclusion criteria:

1. People who speak Mizo and have lived in Mizoram for at least 15 years and have been exposed to Lusei dialect.
2. People who regularly speak the dialect at home.
3. Individuals with no history of any speech, language and hearing problem.
4. No structural or functional deficits based on oro-motor examination.

Exclusion criteria:

1. Individuals who speak Lusei dialect for less than 15 years.
2. Do not use the dialect at home and on a regular basis.
3. Individuals with a history of speech, language and hearing problem.
4. No structural or functional deficits based on oro-motor examination

3.2 Stimuli

A list of thirty-two Mizo sentences, with the first eight target words or sentences containing all of the four tones exist in Mizo which are High, Low, Rising and Falling and the other twenty-four target words or sentences, containing at least three tones in Mizo which are either High, Low, Rising and Falling.

3.2.1 Preparation of the word list

Mizo words were taken, which, despite having a comparable literary form, can have diverse meanings depending on how it is spoken. A sentence was constructed using the thirty-two target words. Each of the target words has different tones in Mizo.

Table 3.2 *Stimulus used for recording*

Sl. No	Words	Meaning	Tone	Sentence
1	thang	trap	rising	Kan huanah *thang* an kam.
2	thang	greasy	low	An bawlhhlawh dahkhawm chu a *thang* huam mai.

3	thang	famous	high	Mawii chu zaithiamin a *thang* nasa hle.
4	thang	Gone away	falling	Liani zin chu a *thang* rei ta vang vang hle mai.
5	Vai	chaff	high	Buh *vai* hi fai takin then tur
6	Vai	wave	Low	Ka thiante nen hla tak atangin kan *vai* nasa mai.
7	Vai	dazzle	falling	Ka tluk sualna lamah ka *vai* ruai mai.
8	Vai	search	rising	Thosi I han *vai* tak tak teh ang.
9	Kan	Crossing road	falling	Motor tam lai taka kawng *kan* chu a harsa hle mai
10	Kan	fry	low	Kan arsa *kan* chu a tui khawp mai.
11	Kan	us	rising	Zaikhawm chu

				nuam *kan* ti tlang hle mai.
12	hlim	happy	high	Chhungkua in kan *hlim* tlang hle mai.
13	hlim	shade	falling	Thing buk *hlim* hnuaia awm chu a hahdamthlak e.
14	hlim	remove	rising	Thli thawin ka pawnfen a *hlim* nasa mai.
15	lei	tongue	High	Ka *lei* a na.
16	lei	bridge	low	Hmanhmawh takin *lei* kan kan.
17	lei	buy	rising	Ka nu kawr min *lei* chu hak anuam lutuk
18	kawr	shirt	rising	Ka nu *kawr* thar min lei chu a mawi lutuk
19	kawr	wrapper	High	A present tuamna *kawr* chu a mawi hle mai.
20	kawr	draina	low	Kawngsir *kawr* rim

		ge		chu a rimchhe hle mai.
21	sawm	invite	rising	Ka pi ten chaw eitur in min <u>*sawm*</u>
22	sawm	ten	low	Chaw ei turin mi <u>*sawm*</u> vel kan kal.
23	sawm	mash	falling	Naute chaw eitur kan deng <u>*sawm*</u>.
24	chhum	cloud	rising	Vawiin khua chu <u>*chhum*</u> a zing nasa ngei mai.
25	chhum	To break	low	Ar lu an sat <u>*chhum*</u>.
26	chhum	boil	falling	Artui ka <u>*chhum.*</u>
27	dawt	lies	high	<u>*Dawt*</u> sawi chin hi a tha lo.
28	dawt	In order	low	In tur kha a in *dawt* zelin lo rem rawh
29	dawt	drink	rising	In tur chu a <u>*dawt*</u> khawlh khawlh mai

30	tui	tasty	high	kan chaw ei chu *tui* kan ti tlang hle.
31	tui	water	rising	Kan thei ei chuan *tui* a ti hal duh hle mai.
32	tui	interes t	falling	A hnathawh chu a *tui* chi tak ani.

3.3 Procedure

Recording:

The participants were informed about the nature of the study. A total of thirty-two sentences were given to them. Before the recording, each participant was instructed to read the sentences to become acclimated and familiar with them. The participants were then instructed to read the sentences aloud and clearly. The Sony MDR-ZX 110AP was used to record the production of the participants with no delay and delays of 50ms, 200ms and 300ms while reading the sentences. And frequencies were altered at 4Hz, 6Hz, 8Hz and 10Hz. For each delay and frequency, a separate recording was made. The delay interval and frequency changes were made using DAF Professional app. Counterbalancing was done for each participant while recording. Each utterance was recorded as a .wav sound file using Praat using a microphone attached to a laptop.

3.4 Data Analysis:

Target words were taken after each sentence had been recorded. Each sample was annotated by being converted to a Praat text grid file. The annotated text grid file was subjected to the Praat script. It generated an excel sheet of the segmented sample's average f0, duration and f0 at every 2%, 4%, 6%......100%. There were 52 samples for each speaker. We obtained 780 samples for men, 780 samples for women and 1560 samples altogether. Speaker discrepancies were eliminated using Z-score normalization. The z-score normalization procedure is as follows:

NPn= normalized z-score of a sampling point

X= average F0 of all sampling points

F0i= sampling point

SD= standard deviation of the average of all the sampling

Each speaker's normalized z score was divided into a separate excel sheet. Following normalization, the samples were organized speaker by speaker and by tones like High, Low, Rising and Falling. It is once more set up with regard to frequency and delay, that is 4Hz, 6Hz, 8Hz and 10Hz frequency and 0ms, 50ms, 200ms and 300ms delay respectively.

3.5 Acoustic Analysis

1. Fundamental Frequency: The segmented target word's mean fundamental frequency was extracted using the Praat script, and the tones were averaged separately for males and females' tones.
2. Duration: The target word's duration was extracted from the Praat script and averaged to represent the duration of each tone.

Each tone's pitch contour will be displayed in a single combined graph

***Statistical analysis*:**

Using the "SPSS 23.0" software, the data was statistically analyzed. To address the research question, statistical analysis test such as Two-way repeated measures ANOVA was used. Since 0ms had no counterparts paired T-test was used to compare 0ms with different delays and frequencies. Four participants data were removed as they were outliers throughout.

CHAPTER IV

RESULTS

The primary aim of the present study was to investigate the effect of the altered feedback conditions including Frequency Altered Feedback (FAF) and Delayed Auditory Feedback (DAF) on acoustic parameters of Lexical Tones in Mizo language. The data were initially subjected to test of normality. After four outliers were eliminated, more than 90% variables were normally distributed. Therefore, parametric test was selected, and it was required to explain the interaction as well. The result of the study is discussed in the following:

4.1 Fundamental Frequency:

4.1.1 Comparison of High Tone F0 values at different delays (50ms, 200ms and 300ms) and frequency-altered frequencies (4Hz, 6Hz, 8Hz and 10Hz)

Two-way repeated measures ANOVA was used, and the results showed,

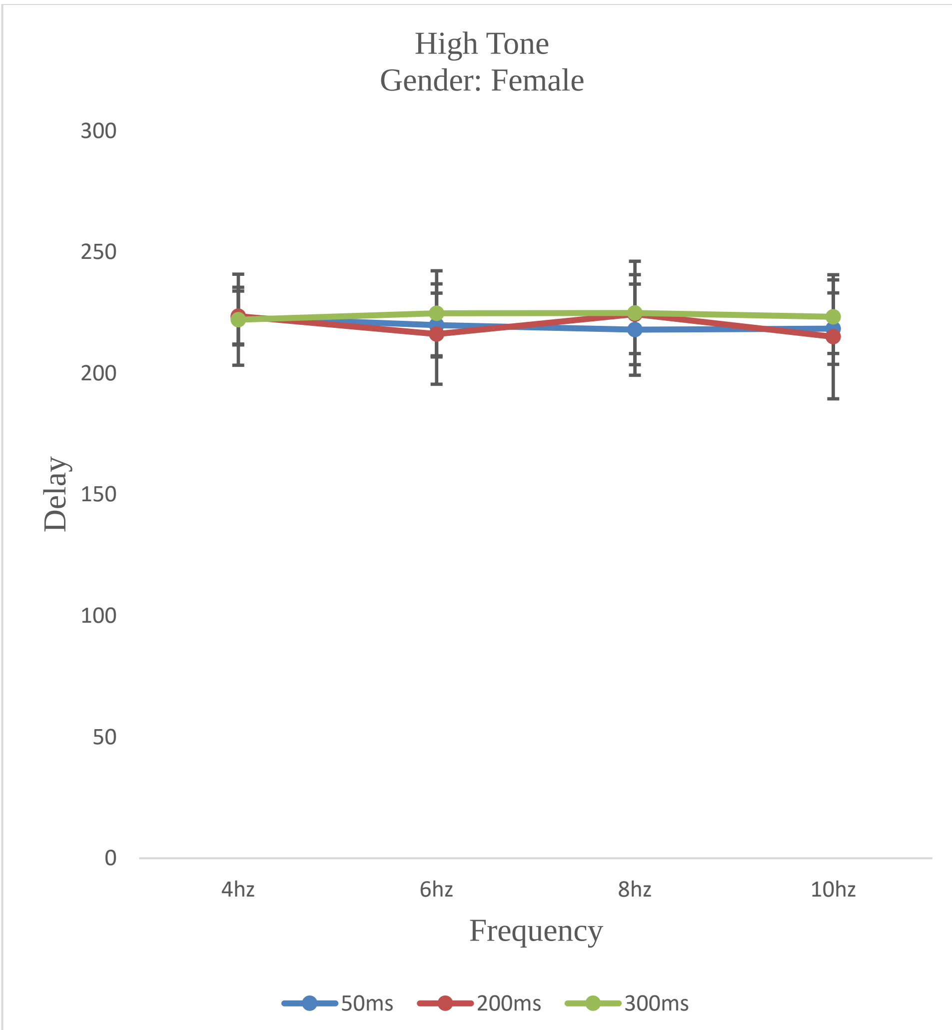
In females,

1. DAF condition: $F(2, 22) = 1.363$, $p > 0.05$, indicating there was no significant effect between three delays on the fundamental frequency.
2. FAF condition: $F(3, 33) = 0.841$, $p > 0.05$, indicating that there was no effect between four frequencies.

With respect to the interaction's effect $F(6, 66) = 1.068$, $p > 0.05$, indicating there was no significant interaction between Delay and Frequency. A Paired T-test was conducted to compare no delay condition i.e., 0ms with delayed and frequency altered conditions with respect to delay and frequency. The results indicated that there was no significant difference between no delay condition and delayed and frequency altered conditions ($p > 0.05$).

Figure 4.1

Changes in High Tone F0 values across different delay and FAF conditions (Error bars indicate SD values)



In males,

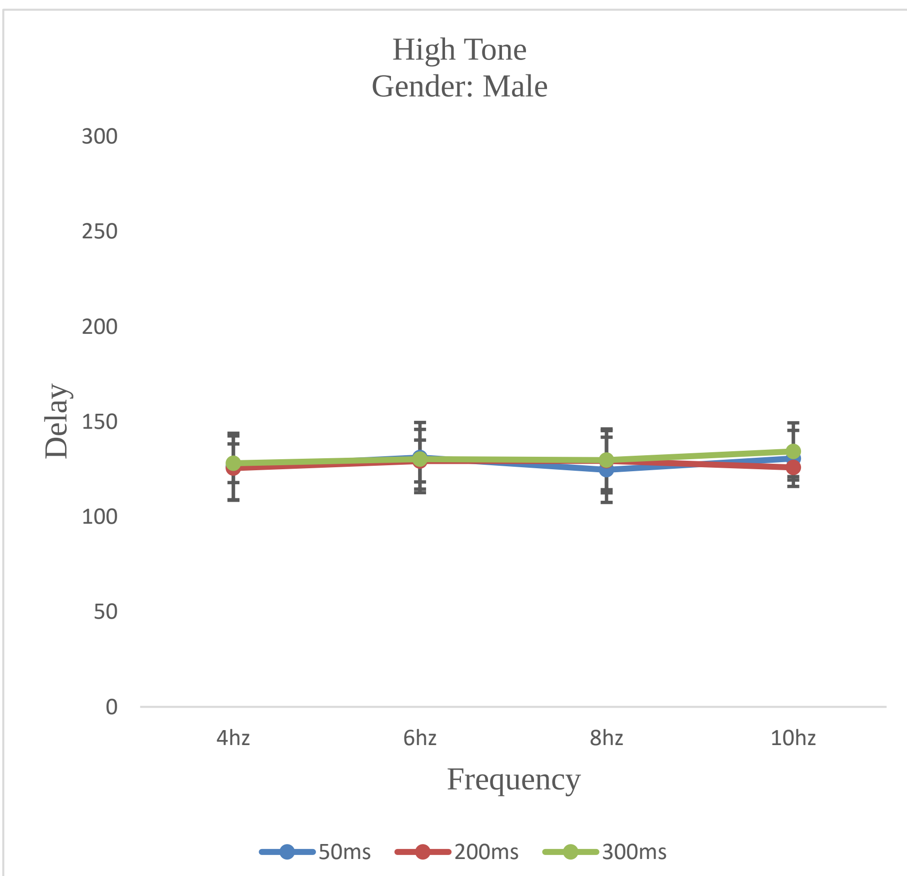
1. DAF condition: F (2, 26) = 0.56, p > 0.05, indicating there was no significant effect between three delays on the fundamental frequency.

2. FAF condition: $F (3, 39) = 1.68$, $p > 0.05$, indicating that there was no effect between four frequencies.

With respect to the interaction's effect paired t-test was performed with $F (6, 78) = 1.31$, $p > 0.05$, indicating there was no significant interaction between delay and frequency. A paired t-test was conducted to compare no delay condition i.e., 0ms with delayed and frequency altered conditions with respect to duration and frequency. The results indicated that there was no significant difference between no delay condition and delayed and frequency altered conditions ($p > 0.05$)

Figure 4.2

Changes in High Tone F0 values across different delay and FAF conditions (Error bars indicate SD values)



4.1.2 Comparison of Low Tone F0 values at different delays (50ms, 200ms and 300ms) and frequency-altered frequencies (4Hz, 6Hz, 8Hz and 10Hz)

Two-way repeated measures ANOVA was used, and the results showed,

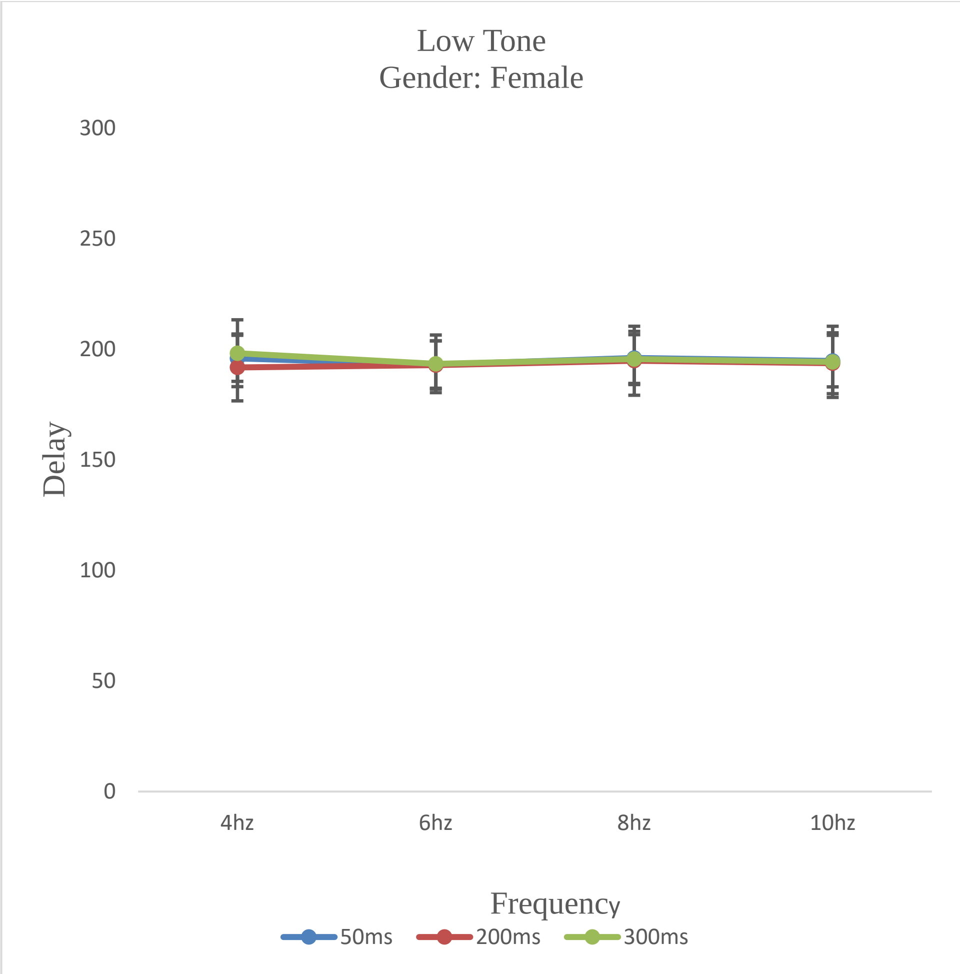
In females,

1. DAF condition: $F (2, 22) = 1.022$, $p > 0.05$, indicating there was no significant effect between three delays on the frequency.
2. FAF condition: $F (3, 33) = 1.55$, $p > 0.05$, indicating that there was no effect between four frequencies.

With respect to the interaction's effect $F (6, 66) = 0.068$, $p > 0.05$, indicating there was no significant interaction between Delay and Frequency. A Paired T-test was conducted to compare no delay condition i.e., 0ms with delayed and frequency altered conditions with respect to duration and frequency. The results indicated that there was no significant difference between no delay condition and delayed and frequency altered conditions ($p > 0.05$).

Figure 4.3

Changes in Low Tone F0 values across different delay and FAF conditions (Error bars indicate SD values)



In males,

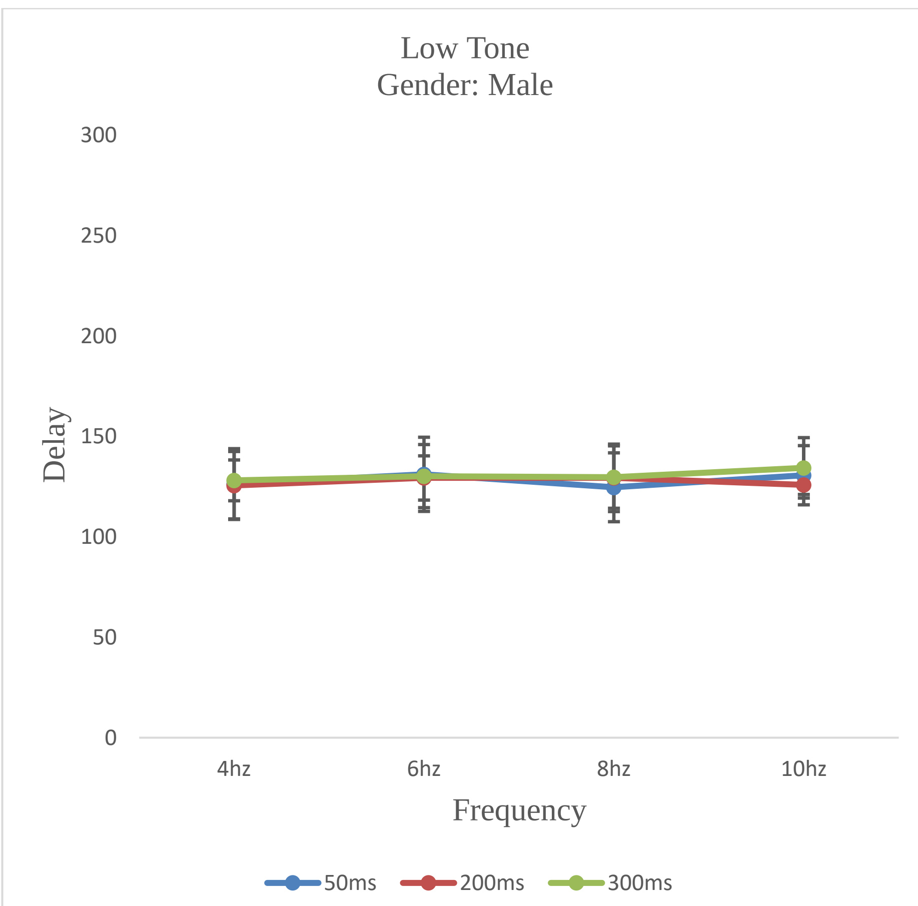
1. DAF condition: F (2, 26) = 0.228, p > 0.05, indicating there was no significant effect between three delays on the fundamental frequency.

2. FAF condition: $F(3, 39) = 2.108$, $p > 0.05$, indicating that there was no effect between four frequencies.

With respect to the interaction's effect $F(6, 78) = 1.088$, $p > 0.05$, indicating there was no significant interaction between Delay and Frequency. A Paired T-test was conducted to compare no delay condition i.e., 0ms with delayed and frequency altered conditions with respect to duration and frequency. The results indicated that there was no significant difference between no delay condition and delayed and frequency altered conditions ($p > 0.05$).

Figure 4.4

Changes in Low Tone F0 values across different delay and FAF conditions (Error bars indicate SD values)



4.1.3 Comparison of Rising Tone F0 values at different delays (50ms, 200ms and 300ms) and frequency-altered frequencies (4Hz, 6Hz, 8Hz and 10Hz)

Two-way repeated measures ANOVA was used, and the results showed,

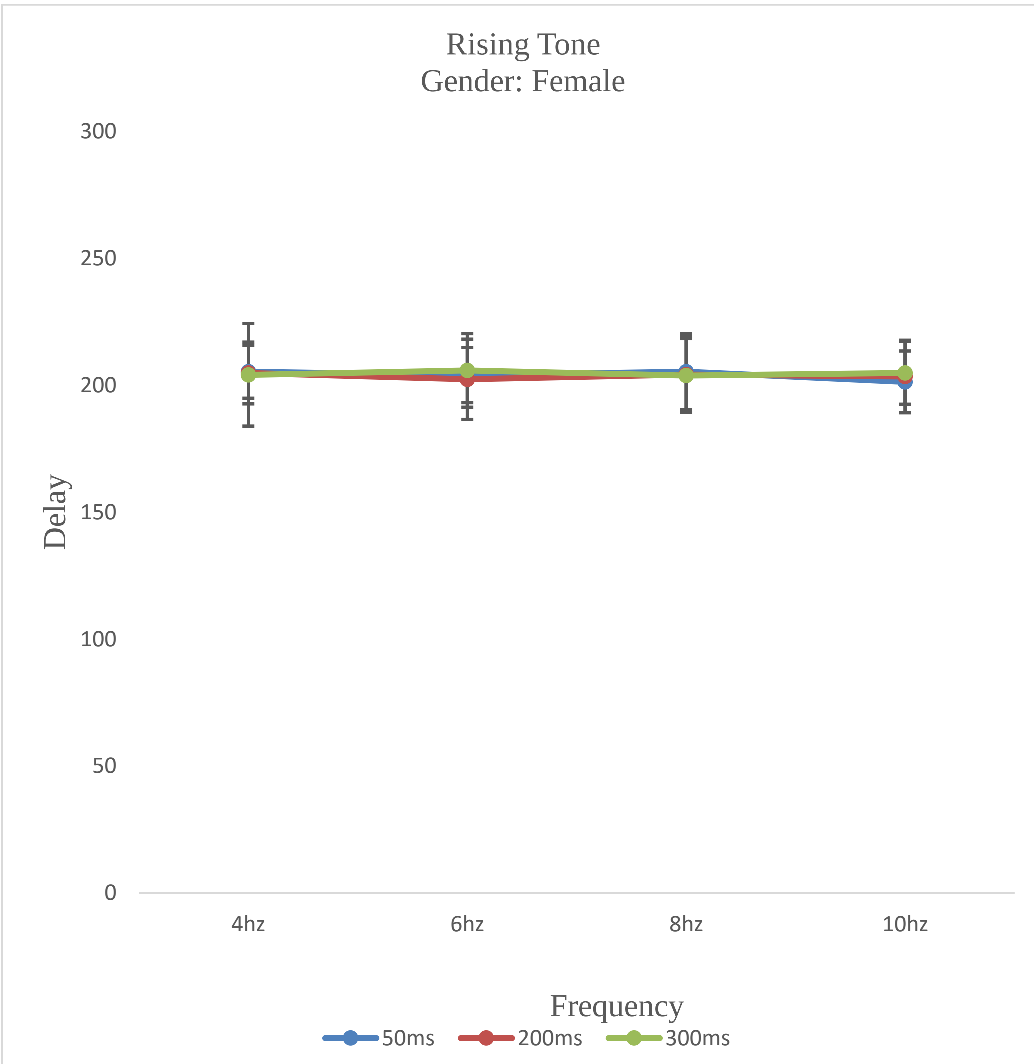
In females,

1. DAF condition: $F(2, 22) = 0.126$, $p > 0.05$, indicating there was no significant effect between three delays on the fundamental frequency.
2. FAF condition: $F(3, 33) = 0.420$, $p > 0.05$, indicating that there was no effect between four frequencies.

With respect to the interaction's effect $F(6, 66) = 0.661$, $p > 0.05$, indicating there was no significant interaction between Delay and Frequency. A Paired T-test was conducted to compare no delay condition i.e., 0ms with delayed and frequency altered conditions with respect to duration and frequency. The results indicated that there was no significant difference between no delay condition and delayed and frequency altered conditions ($p > 0.05$).

Figure 4.5

Changes in Rising Tone F0 values across different delay and FAF conditions (Error bars indicate SD values)



In males,

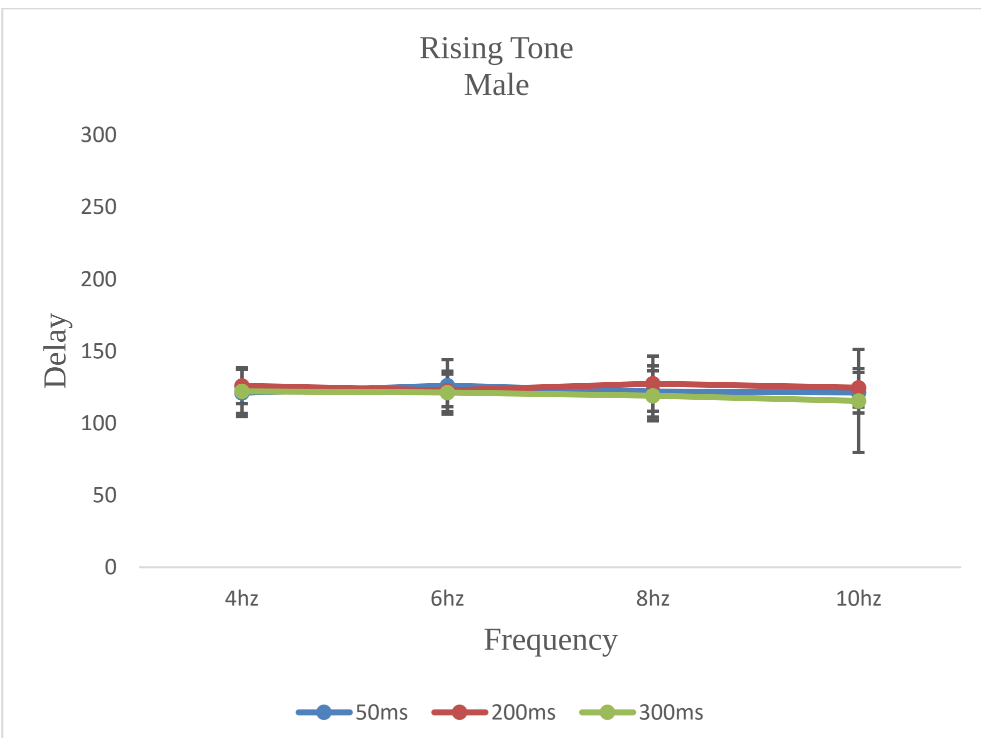
1. DAF condition: F (2, 26) = 1.499, p > 0.05, indicating there was no significant effect between three delays on the fundamental frequency.

2. FAF condition: F (3, 39) = 0.646, p > 0.05, indicating that there was no effect between four frequencies.

With respect to the interaction's effect F (6, 78) = 0.646, p > 0.05, indicating there was no significant interaction between Delay and Frequency. A Paired T-test was conducted to compare no delay condition i.e., 0ms with delayed and frequency altered conditions with respect to duration and frequency. The results indicated that there was no significant difference between no delay condition and delayed and frequency altered condition (p > 0.05).

Figure 4.6

Changes in Rising Tone F0 values across different delay and FAF conditions (Error bars indicate SD values)



4.1.4 Comparison of Falling Tone F0 values at different delays (50ms, 200ms and 300ms) and frequency-altered frequencies (4Hz, 6Hz, 8Hz and 10Hz)

Two-way repeated measures ANOVA was used, and the results showed,

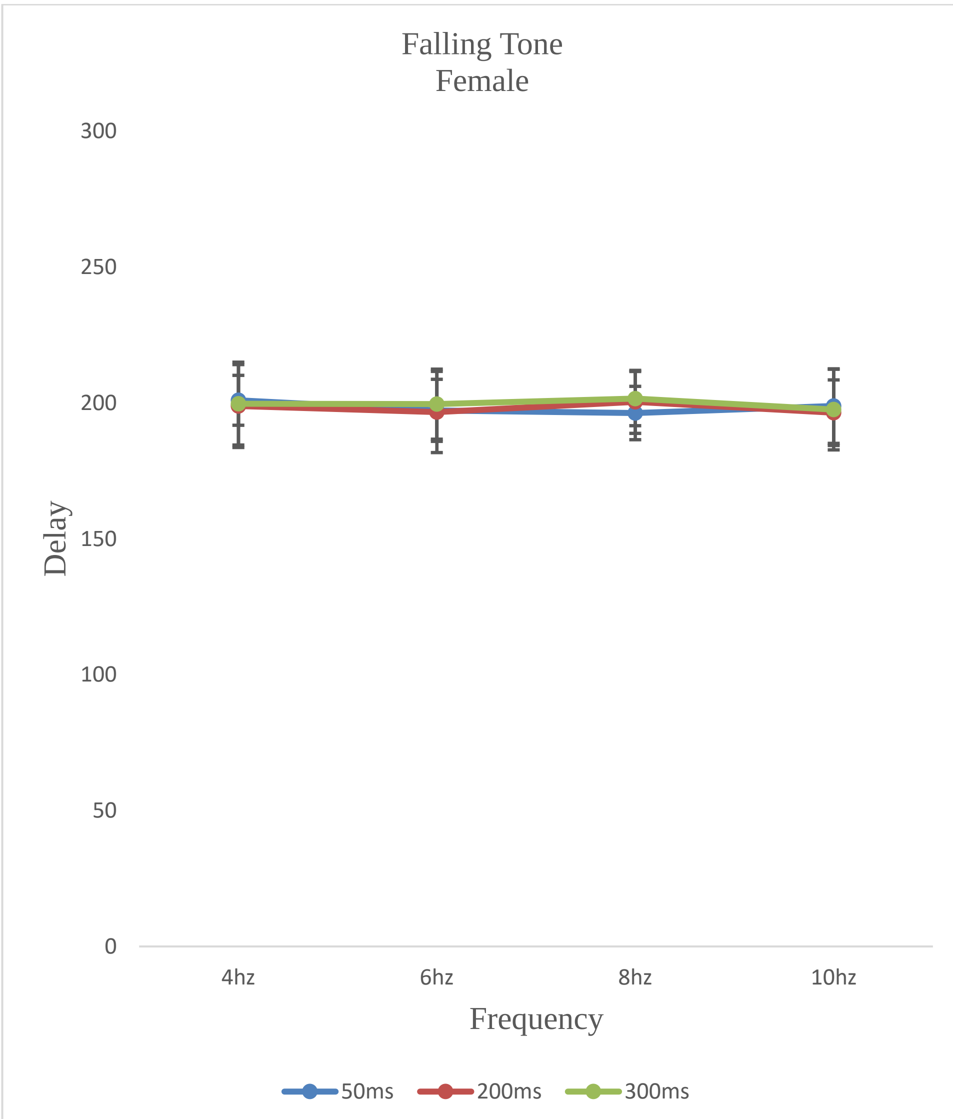
In females,

1. DAF condition: F (2, 22) = 0.512, p > 0.05, indicating there was no significant effect between three delays on the fundamental frequency.
2. FAF condition: F (3, 33) = 1.536, p > 0.05, indicating that there was no effect between four frequencies.

With respect to the interaction's effect F (6, 66) = 1.283, p > 0.05, indicating there was no significant interaction between Delay and Frequency. A Paired T-test was conducted to compare no delay condition i.e., 0ms with delayed and frequency altered conditions with respect to duration and frequency. The results indicated that there was no significant difference between no delay condition and delayed and frequency altered conditions (p >0.05).

Figure 4.7

Changes in Falling Tone F0 values across different delays and FAF conditions (Error bars indicate SD values)



In males,

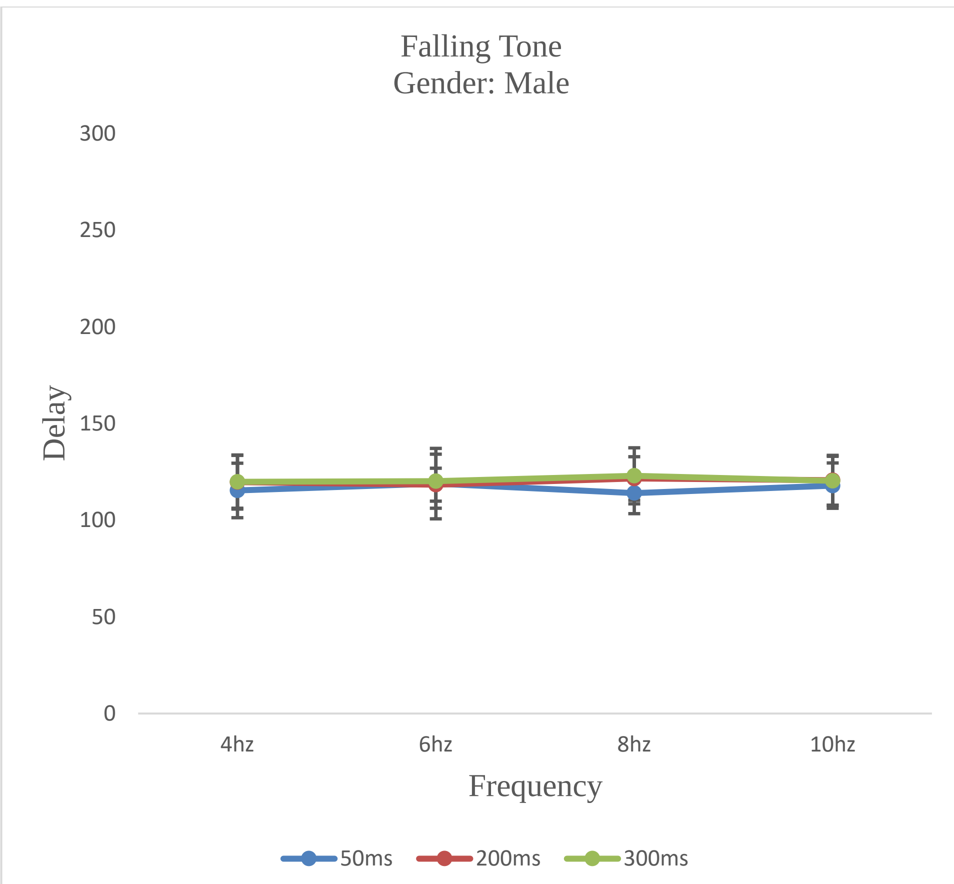
1. DAF condition: F (2, 26) = 2.196, p > 0.05, indicating there was no effect between three delays on the frequency.

2. FAF condition: F (3, 39) = 0.384, $p > 0.05$, indicating that there was no effect between four frequencies.

With respect to the interaction's effect F (6, 78) = 0.259, $p > 0.05$, indicating there was no significant interaction between Delay and Frequency. A Paired T-test was conducted to compare no delay condition i.e., 0ms with delayed and frequency altered conditions with respect to duration and frequency. The results indicated that there was no significant difference between no delay condition and delayed and frequency altered condition ($p > 0.05$).

Figure 4.8

Changes in Low Tone F0 values across different delays and FAF conditions (Error bars indicate SD values)



In summary, the statistical analysis in the study found no significant effects of either the different delays or the different frequencies on the Lexical tones of Mizo language in both the DAF and FAF conditions. Additionally, there was no significant interaction between Delay and Frequency. Finally, the paired T-test results confirmed the absence of significant differences between the "no delay" condition and the "delayed and frequency altered" condition.

4.2 Duration:

4.2.1 Comparison of High Tone Duration values at different delays (50ms, 200ms and 300ms) and frequency-altered frequencies (4Hz, 6Hz, 8Hz and 10Hz)

RANOVA was used to evaluate the effect of duration.

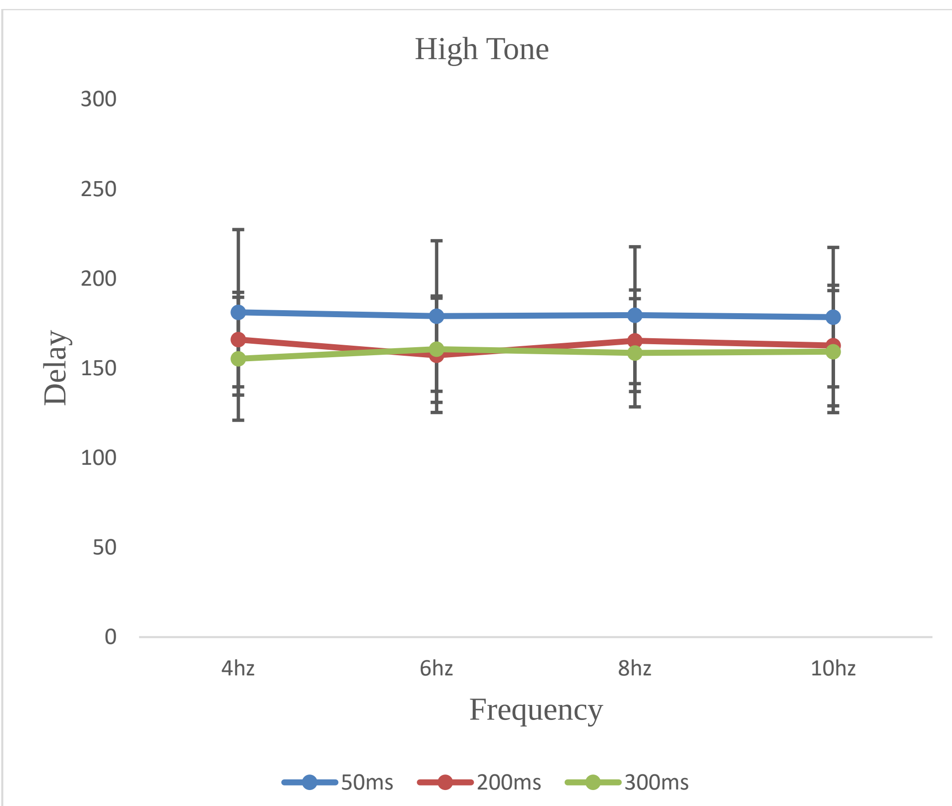
1. Effect of delay: The analysis of duration parameter revealed significant main effect of delay condition [$F(2, 50) = 10.78$, $p < 0.001$].
2. Effect of frequency: The analysis of duration parameter across different frequency-altered auditory feedback conditions revealed no significant main effect of the FAF conditions [$F(3, 75)$] = 0.210, $p > 0.05$].
3. Interaction effect: The analysis of the interaction effect, which likely involved both duration and frequency as factors, also did not yield statistically significant results. The [$F(6,150)$] = 0.875, $p > 0.05$], indicates that there was no significant when considering both the delay and frequency conditions together.
4. Post hoc analysis: Post hoc analysis, specifically the Bonferroni test, was conducted to further explore the differences between specific conditions. The test found significant differences between 50ms and 200ms, 50ms and 300ms, and 200ms and 300ms. However, there was no significant difference between 200ms and 300ms. Specifically, there was a

substantial impact of a 50ms delay compared to 200ms and 300ms. indicated that there was a significant difference in duration when comparing the 50ms duration to 200ms and 300ms.

5. Paired T-test: A paired T-test was used to compare the "no delay" condition (0ms) with the "delayed and frequency altered" conditions in terms of both duration and frequency. The results indicated significant differences between the "no delay" condition and the altered conditions, all conditions displayed longer in duration except for the cases of 200ms at 6Hz and 300ms at 4Hz, where there were no significant differences.

Figure 4.9

Changes in High Tone Duration values across different delays and FAF conditions (Error bars indicate SD values)



4.2.1 Comparison of Low Tone Duration values at different delays (50ms, 200ms and 300ms) and frequency-altered frequencies (4Hz, 6Hz, 8Hz and 10Hz)

RANOVA was used to evaluate the effect of duration.

1. Effect of delay: The analysis of duration parameter revealed significant main effect of delay condition [F (2, 50) = 6.303, p < 0.05].

2. Effect of frequency: The analysis of duration parameter across different frequency-altered auditory feedback conditions revealed no significant main effect of the FAF conditions [F (3, 75)] = 1.273, p > 0.05].

3. Interaction effect: The analysis of the interaction effect, which likely involved both duration and frequency as factors, also did not yield statistically significant results. The, [F (6,150)] = 0.885, p > 0.05, indicates that there was no significant when considering both the delay and frequency conditions together.

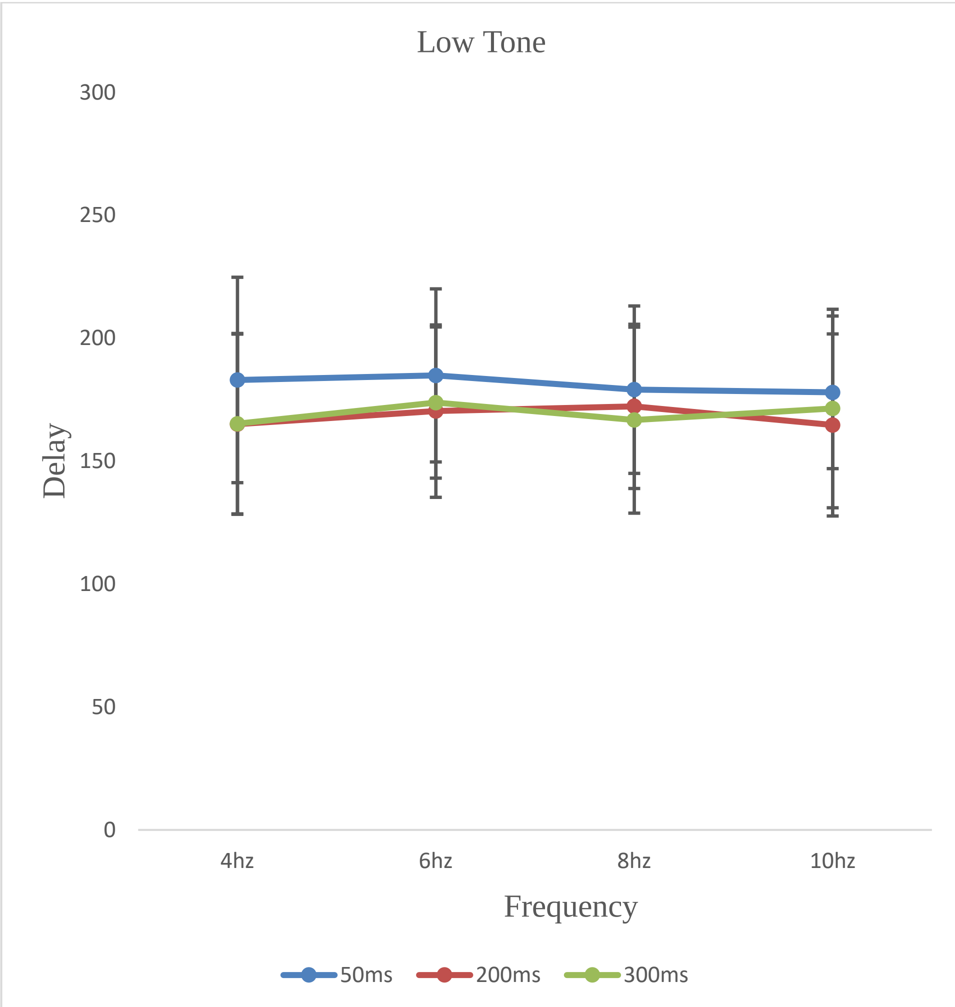
4. Post hoc analysis: Post hoc analysis, specifically the Bonferroni test, was conducted to further explore the differences between specific conditions. The test found significant differences between 50ms and 200ms, 50ms and 300ms, and 200ms and 300ms. However, there was no significant difference between 200ms and 300ms. Specifically, there was a substantial impact of a 50ms delay compared to 200ms and 300ms.

5. Paired T-test: A paired T-test was used to compare the "no delay" condition (0ms) with the "delayed and frequency altered" conditions in terms of both duration and frequency. The results indicated significant differences between the "no delay" condition and the altered conditions, all conditions displayed longer in duration except for the cases of 200ms at 4Hz, where there were no significant differences.

Figure 4.10

Changes in Low Tone Duration values across different delays and FAF conditions

(Error bars indicate SD values)



4.2.3 Comparison of Rising Tone Duration values at different delays (50ms, 200ms and 300ms) and frequency-altered frequencies (4Hz, 6Hz, 8Hz and 10Hz)

RANOVA was used to evaluate the effect of duration.

1. Effect of delay: The analysis of duration parameter revealed significant main effect of delay condition [F (2, 50) = 4.58, p < 0.05].

2. Effect of frequency: The analysis of duration parameter across different frequency-altered auditory feedback conditions revealed no significant main effect of the FAF conditions [F (3, 75) = 0.346, p > 0.05].

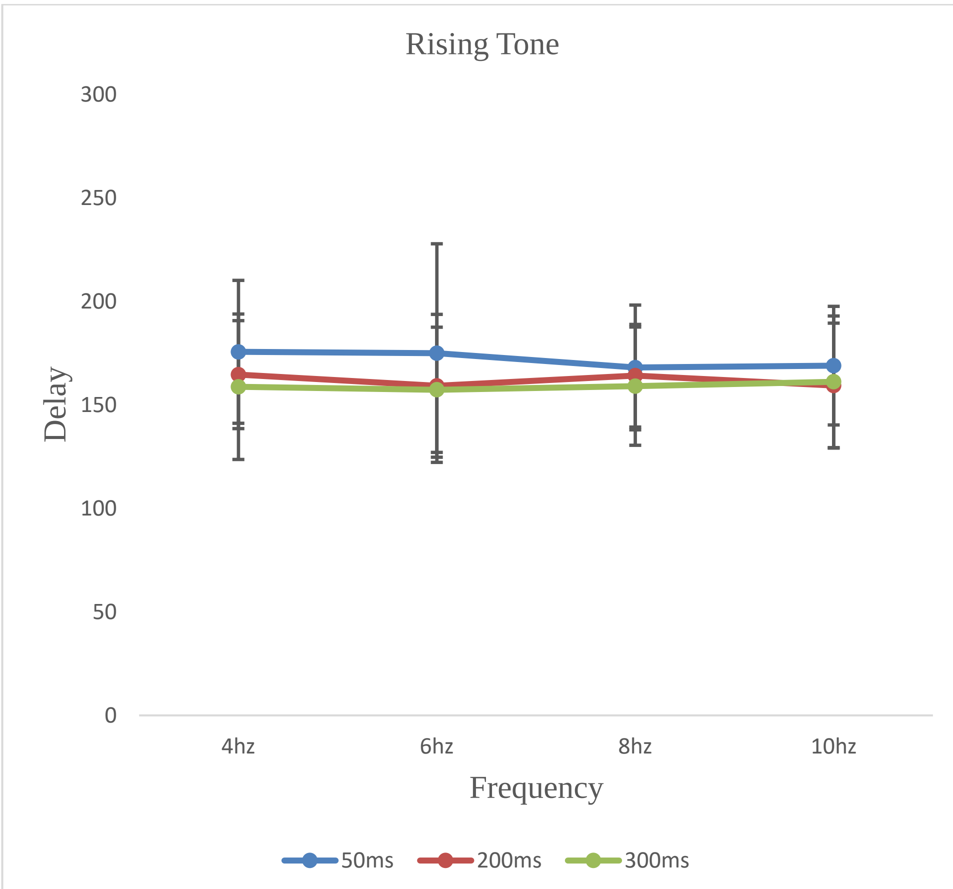
3. Interaction effect: The analysis of the interaction effect, which likely involved both duration and frequency as factors, also did not yield statistically significant results. The, [F (6,150)] = 0.698, p > 0.05, indicates that there was no significant when considering both the delay and frequency factors together.

4. Post hoc analysis: Post hoc analysis, specifically the Bonferroni test, was conducted to further explore the differences between specific conditions. The test found significant differences between 50ms and 200ms, 50ms and 300ms, and 200ms and 300ms. However, there was no significant difference between 200ms and 300ms. Specifically, there was a substantial impact of a 50ms delay compared to 200ms and 300ms.

5. Paired T-test: A paired T-test was used to compare the "no delay" condition (0ms) with the "delayed and frequency altered" conditions in terms of both duration and frequency. The results indicated significant differences between the "no delay" condition and the altered conditions, all conditions displayed longer in duration with the exception of 50ms at 4Hz, 6Hz, 8Hz and 10Hz (p < 0.05).

Figure 4.11

Changes in Rising Tone Duration values across different delays and FAF conditions (Error bars indicate SD values)



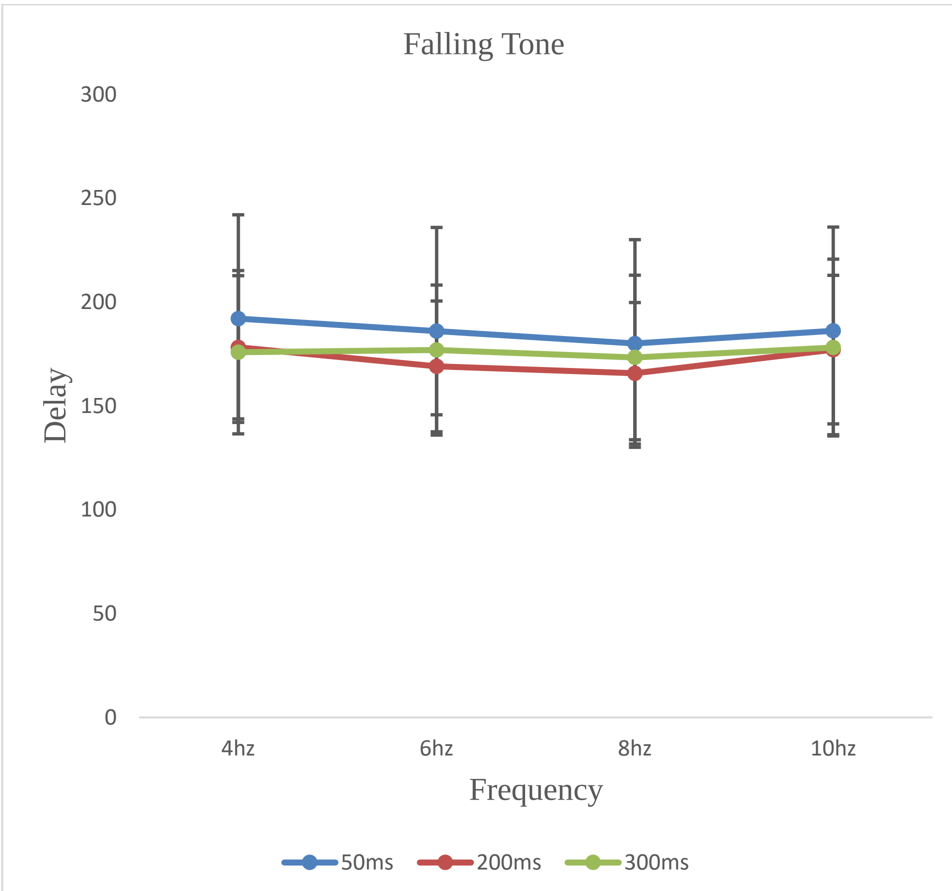
4.2.4 Comparison of Falling Tone Duration values at different delays (50ms, 200ms and 300ms) and frequency-altered frequencies (4Hz, 6Hz, 8Hz and 10Hz)

RANOVA was used to evaluate the effect of duration.

1. Effect of delay: The analysis of duration parameter revealed significant main effect of delay condition [F (2, 50) = 3.573, $p < 0.05$].
2. Effect of frequency: The analysis of duration parameter across different frequency-altered auditory feedback conditions revealed no significant main effect of the FAF conditions [F (3, 75) = 3.692, $p > 0.05$].
3. Interaction effect: The analysis of the interaction effect, which likely involved both duration and frequency as factors, also did not yield statistically significant results. The, [F (6,150)] = 0.904, $p > 0.05$, indicates that there was no significant when considering both the delay and frequency factors together.
4. Post hoc analysis: Post hoc analysis, specifically the Bonferroni test, was conducted to further explore the differences between specific conditions. The test found significant differences between 50ms and 200ms, 50ms and 300ms, and 200ms and 300ms. However, there was no significant difference between 200ms and 300ms. Specifically, there was a substantial impact of a 50ms delay compared to 200ms and 300ms.
5. Paired T-test: A paired T-test was used to compare the "no delay" condition (0ms) with the "delayed and frequency altered" conditions in terms of both duration and frequency. The results indicated significant differences between the "no delay" condition and the altered conditions across all conditions, so all conditions displayed longer in duration ($p < 0.05$).

Figure 4.12

Changes in Falling Tone Duration values across different delays and FAF conditions (Error bars indicate SD values)



In summary, the statistical analysis examined the effects of duration and frequency on the different lexical tones of Mizo language. It was found that a 50ms delay had a significant impact across all tones i.e., High, Low, Rising and Falling, while changes in frequency had significant effect only on Falling tone. The interaction between duration and frequency was also not significant. Post hoc tests revealed specific differences between some conditions, and the paired T-tests showed significant differences in most cases when comparing the "no delay" condition to the altered conditions, except for a few specific combinations.

CHAPTER V

DISCUSSION

The current study explores the effect of frequency altered feedback and delayed auditory feedback on lexical tones of Mizo language. The goal of this study was to determine if there were any changes when providing delays and changing the pitch at various frequencies. Only a few research in tonal languages have been conducted and this study is one of the first studies in North Eastern languages. The study recruited thirty participants, 15 of whom were male and 15 of whom were female. The first eight words from the thirty-two Mizo phrases contained all four tones which are High, Low, Rising and Falling, and the remaining twenty-four words contained at least three tones in Mizo which are either High, Low, Rising and Falling. While reading the sentences, Sony MDR-ZX 110AP was used to record the production of the participants with no delay and delays of 50ms, 200ms and 300ms. Further, frequencies were altered at 4Hz, 6Hz, 8Hz and 10Hz and delay of 50ms, 200ms and 300ms were provided using DAF Professional App. Counterbalancing was applied to ensure that all participants experienced the various feedback conditions. Each utterance was recorded using Praat and saved it as .wav file and analyzed using Praat. Speaker discrepancies were eliminated using Z-score normalization. Using "SPSS 23.0" software, the data was statistically analyzed.

5.1 Comparison of the Fundamental Frequency of Delays at different frequencies, including 4Hz, 6Hz, 8Hz and 10Hz of High, Low, Rising and Falling Tone, of 50ms, 200ms and 300ms

The current study found no significant effect of different delays such as 50ms, 200ms and 300ms on the fundamental frequency of Mizo lexical tones including High, Low, Rising and Falling tone. The present study also revealed that the frequency modulation of 4Hz, 6Hz, 8Hz and 10Hz had no significant effect on the fundamental frequency of Mizo lexical tones comprising of High, Low, Rising and Falling tone. Aside from this, it is clear from the statistical findings that there was no significant interaction between delays and frequency. When comparing a no delay condition i.e., 0ms with the delayed and frequency altered conditions, it was found that there was no significant difference between no delay condition and frequency altered condition. The findings of the result with regards to fundamental frequency is consistent for all High, Low, Rising and Falling tone.

In a study done by Keough et al. (2013)wherein participants experience auditory-motor adaptation to frequency-altered feedback when they ignore feedback. The participants were made aware that their auditory feedback will be altered in pitch when they sang the target vowel /a/ for trained singers and musically untrained singers (non-singers). They were asked to ignore or compensate the changes in auditory feedback. The participants' objective was to match the pitch of their voice as closely as possible to the altered pitch presented while ignoring the auditory feedback. Regardless of whether they were instructed to account for or ignore the FAF, the fundamental frequency of the participants did not differ significantly across all trials. Other noteworthy main effects or interactions were not observed. This study supports the results of the current study, wherein all altered frequency conditions had no effect on the fundamental frequency of lexical tones of Mizo language, suggesting a potential similarity in how individuals adapt to and maintain pitch consistency in response to changes in auditory feedback.

The study by Xu and Meng, (2010) where the voice pitch and speed control in standard Chinese and Japanese speakers under Frequency Modulated Auditory Feedback conditions was studied, it was found that in FAF condition, Chinese had a larger pitch reduction than Japanese did. There were significant differences between the two group i.e., Chinese and Japanese with the exception of 0.1Hz. This is in contrast to the findings of the current study, wherein there were no significant effect of FAF on fundamental frequency of all tone of Mizo language which include High, Low, Rising and Falling. This suggests that the effects of FAF on voice pitch control may vary across different languages and speech patterns.

In a study by Jones and Munhall (2002), where the role of auditory feedback during phonation is studied in Mandarin tone production, it was found that when F0 is suddenly shifted upward or downward, subjects compensated by shifting their voice fundamental frequency in opposite direction. Subjects decreased their pitch when the F0 was shifted up, and increased when it was shifted downwards. A sensorimotor adaptation was also seen in the participants. After being subjected to the different feedback conditions, significant aftereffects were seen when F0 was reverted to normal. This is in contrast to the findings of the current study, wherein F0 was found to have no effect on auditory feedback in Mizo lexical tones. It is important to note that language-specific factors, such as tonal systems and phonetic characteristics, can influence how individuals respond to auditory feedback perturbations. Mandarin Chinese and Mizo are different languages with distinct tonal systems, which may lead to variations in how speakers adapt to changes in F0 feedback. These differences highlight the importance of considering language-specific factors and the complexity of auditory feedback control in speech production.

5.2 Comparison of the Duration of Delays at different frequencies, including 4Hz, 6Hz, 8Hz and 10Hz of High, Low, Rising and Falling Tone, of 50ms, 200ms and 300ms

In the current study, it was found that a 50ms delay had a significant effect on the duration of all lexical tones of Mizo language such as High, Low, Rising and Falling, while no significant effect of 200ms and 300ms delay on duration was observed. It also revealed that there was no significant variation in duration for frequencies i.e., 4Hz, 6h, 8Hz and 10Hz for High, Low, Rising and Falling tone except for Falling tone wherein a significant effect was observed with $p < 0.05$. The results also suggested that there was no significant interaction between delays and frequencies. All of the tones displayed longer duration at a 50ms delay. The findings of the results with regards to duration is consistent for all High, Low, Rising and Falling tone.

The results of the current study also indicated that there was no significant difference between the no delay i.e., 0ms condition and delayed and frequency altered condition in the High tone, with the exception of 200ms at 6Hz and 300ms at 4Hz. No significant difference was noticed for Low tone and Rising tone under no delay, delayed and frequency altered conditions, with the exception of 200ms at 4Hz for Low tone and 50ms at 4Hz, 6Hz, 8Hz and 10Hz. Between the no delay i.e., 0ms and delayed and frequency altered conditions, there was a significant difference for the Falling tone.

These results provide valuable insights into the relationship between delay and tone duration in Mizo language. The fact that a 50ms delay consistently affected the duration of all tones while longer delays did not have a significant impact suggests that there might be a specific temporal window within which these tones are sensitive to auditory feedback. Additionally, the lack of interaction with frequency implies that this effect is not frequencydependent.

A study done in Italian by Zanini et al, (1999) found that delayed feedback had a disruptive effect at a normal speaking rate. More errors were made when the auditory input was given to the right ear than to the left, and binaurally than monoaurally. Syllable lengthening, syllable repetition and paraphasic errors are the most common errors induced by DAF. An explanation given was as when speaking rate is fast, one depends more on central systems of control and monitoring verbal production, including the cortico-thalamus-cortical, cortico-cerebellum-thalamus-cortical and the cortical-corpus-striatum-thalamus-cortical (Borden, 1975). As a result, peripheral sensory circuits become less important. The peripheral feedback loops, which depend on the peripheral activation of sensory receptors triggered by the motor activity itself, are longer and slower because of this. Which means that they are not typically engaged in programming the motor act and that their contribution to motor control is present only at a later stage.

Similar results were found in another study by Stuart et al., (2002) wherein they evaluated how a normal speaker's rate changed when a delay in auditory feedback is provided in English. In comparison to no delay or shorter delays, a measurable two to three times greater number of dysfluencies were observed at 200ms. They found correlation between dysfluencies and high rate of speech. The current study delved into the effects of feedback delays in Mizo language, which is tonal and has different phonological characteristics. Despite the linguistic differences, both studies highlight the disruptive impact of feedback delays on speech production.

The study by Xu and Meng (2010) supports the result of the current study, where the voice pitch and speed control in standard Chinese and Japanese speakers under Frequency

Modulated Auditory Feedback conditions was studied. In DAF condition, except for 50ms delay, no significant group differences were observed. Even in the voice speed, no significant difference between the two groups were found except for 50ms delay. In the current study, the results revealed that, in DAF condition with respect to duration there was significant effect on 50ms while significant effect was not observed on 200ms and 300ms. The result of the current study also showed similar trend in High tone and Low tone. Although it had an impact on 300ms in both Falling tone and Rising tone, statistical evidence of its significance was not provided. The results of the current study, particularly concerning the effects of DAF with different delay durations, appear to align with the trends observed in Xu and Meng, (2010)'s study with Chinese and Japanese speakers. Both studies highlight the importance of the specific delay duration in understanding the effects of altered auditory feedback on speech production, and they suggest that shorter delays can have a more pronounced impact.

The current study demonstrated that not all evaluated FAF and DAF combinations had significant effects. Regarding fundamental frequency, none of the delays including 50ms, 200ms and 300ms and altered frequencies such as 4Hz, 6Hz, 8Hz and 10Hz had a discernible effect. Regarding duration, there is a noticeable effect on 50ms on all tones i.e., High, Low, Rising and Falling when compared to no effect on 200ms and 300ms. This is confirmed by a study done by Arbabshirani and Shafiei (2014) where they have FAF and DAF conditions on stuttering people. In their study the results suggested that not every combination of FAF and DAF have significant stuttering reduction. In order to get a significant fluency reduction under combined experimental settings, a certain FAF and DAF combination was essential. Both studies underscore the importance of selecting appropriate combinations of FAF and DAF parameters based on the specific speech-related outcome of interest, whether it be lexical tone production or stuttering reduction. Not all combinations are equally effective, and the impact may vary across different aspects.

These findings contribute to our understanding of the acoustic properties and temporal aspects of Mizo lexical tones, and they may have implications for our understanding of how speakers of Mizo language perceive and produce different tones in different contexts. Further research could explore the underlying mechanisms and potential implications of these findings in more detail.

Overall, we can conclude that both FAF and DAF has no significant effect on all lexical tones of Mizo language which are High, Low, Rising and Falling tone with respect to fundamental frequency. When comparing the "no delay" and 'delay and frequency altered" conditions also it does not have any substantial effect on the lexical tones. Whereas there are variations in duration at a delay of 50ms. All the tones i.e., High, Low, Rising and Falling exhibited longer duration at 50ms delay, while statistically no significant effect was observed for 200ms and 300ms delay. From a comparison of a no delay with delay of 50ms, 200ms and 300ms and altered frequency modulation at 4Hz, 6Hz, 8Hz and 10Hz, it indicated that significant difference in duration across "no delay" and "delayed and frequency altered" conditions for all the four tones exists in Mizo. Under all circumstances, participants made errors in their speech when receiving feedback and when changing the pitch.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The current study investigated the effect of altered feedback conditions including Frequency Altered Feedback (FAF) and Delayed Auditory Feedback (DAF) on Acoustic Parameters of Lexical Tones in Mizo language. The study's objectives were to investigate the changes in F0 and Duration of Mizo lexical tones on Frequency Altered Feedback and Delayed Auditory Feedback. A total of thirty neuro-typical adults between the ages of 18 and 30 participated in the study. All participants had good proficiency in Mizo. There were thirty-two target words which contain different tones in Mizo such as High, Low, Rising and Falling. The participants were asked to read sentences and each utterance were recorded. Each sample was annotated by converting into Praat text grid file. The Praat script was run on the annotated text grid file and this generated separate excel sheet of the segmented sample's average f0, duration and f0 every 2%, 4%, 6%......100%. Normalized z-score was done to eliminate speaker differences.

For statistical analysis, two-way repeated ANOVA measures were used. The results of the study showed that when comparing the delays across different frequencies at 4Hz, 6Hz, 8Hz and 10Hz for High tone, Low tone, Rising tone and Falling tone, of 50ms, 200ms and 300ms, there were no significant effect of the altered feedback conditions including Frequency Altered Feedback and Delayed Auditory Feedback on lexical tones of Mizo language. Additionally, there was no significant interaction between delays and frequencies also. To compare the no delay and frequency altered condition with different delayed condition, Paired T-test was used. And the statistical results revealed that there was no significant difference between no delay and delayed with frequency altered condition.

To compare the duration across delays including 50ms, 200ms and 300ms and across different frequencies at 4Hz, 6Hz, 8Hz and 10Hz for High tone, Low tone, Rising tone and Falling tone, RANOVA was used. The results revealed that statistically a 50ms delay had a significant effect when compared to 200ms and 300ms in all tones such as High, Low, Rising and Falling. Whereas with respect to frequency no significant effect on duration was observed for frequencies such as 4Hz, 6Hz, 8Hz and 10Hz. Also, with respect to the interaction there was no significant difference across delays and frequencies.

However, in Paired T-test which was conducted to compare no delay i.e., 0ms and delayed and frequency altered condition with respect to duration and frequency, the results indicated that for High tone there was a significant difference between no delay condition and delayed and frequency altered condition, except for 200ms at 6Hz and 300ms at 4Hz. For Low tone, the results revealed that there was a significant difference between no delay condition and delayed and frequency altered condition, with the exception of 200ms at 4Hz. In Rising tone, no significant difference between no delay condition and delayed and frequency altered condition was observed, with the exception of 50ms at 4Hz, 6Hz, 8Hz and 10Hz. For Falling tone, there was a significant difference across no delay condition with all delayed and frequency altered condition. Although the effect is more pronounced on 300ms than 200ms in Falling tone and 300ms is getting closer to 200ms in Rising tone, it was not statistically significant.

Hence it can be concluded from the current study that, Frequency Altered Feedback and Delayed Auditory Feedback has no effect on F0 of Mizo Lexical Tones. Whereas with respect to the duration it has an effect on 50ms on all tones existing in Mizo i.e., High. Low, Rising and Falling tone. But 200ms and 300ms did not have a significant effect on Lexical tones of Mizo language. Additionally, the study observed that participants experienced speech dysfluencies when exposed to feedback alterations and delays, highlighting the potential challenges introduced by these conditions in speech production.

6.1 Implications of the study:

1. The study contributes to our understanding of the acoustic properties of lexical tones in Mizo language. By investigating the effects of Frequency Altered Feedback (FAF) and Delayed Auditory Feedback (DAF), the study sheds light on how these factors may or may not influence the pitch and duration of lexical tones in Mizo.

2. The finding that FAF and DAF had no significant effect on the fundamental frequency (F0) of Mizo Lexical Tones suggests that the pitch of these tones may be relatively stable and less susceptible to alterations in auditory feedback. This can be important for linguists studying the phonological characteristics of the Mizo language.

3. It could support the provision of sensorimotor phenomena for the generation of tones production.

4. It will be useful in intervention of communication disorder especially in stuttering for persons who speak Mizo language.

5. While this study focused on the Mizo language, the implications can extend to other tonal languages and even non-tonal languages. Understanding how altered auditory feedback affects speech production can have broader applicability in research and speech therapy, potentially informing best practices in language learning and speech improvement.

6.2 Limitations of the study:

1. The participants in the current study were young adults. The results should not, however, be generalized to children and older individuals.

2. It was necessary to eliminate the values for four participants because they showed to be outliers throughout.

3. Since the participants had to read the sentences repeatedly, they had grown accustomed to them in some ways, even when the pitch and delay were changed.

4. The study focused on Mizo language, which is a tonal language with its unique phonological characteristics. The results may not be directly applicable to non-tonal languages or even other tonal languages with different phonetic features.

5. The study examined specific parameters of Frequency Altered Feedback (FAF) and Delayed Auditory Feedback (DAF), such as delay durations and frequency alterations, different parameter settings might yield different results.

6. The study noted the presence of speech dysfluencies under altered feedback conditions, but it did not provide an in-depth analysis of the nature and causes of these dysfluencies. Further research could delve into the underlying mechanisms and implications of these disruptions in speech production.

Future Direction:

1. More delays and pitch modifications could be included in the future studies.
2. Comparing males and females in the same study is possible.
3. Taking into account a larger group of individuals.
4. Compare the effects of altered auditory feedback between tonal languages like Mizo and non-tonal languages. This comparative approach can reveal whether tonal languages exhibit unique responses to altered feedback.

5. Explore the clinical applications of these findings, particularly in speech therapy and the treatment of communication disorders. Understanding how altered feedback influences speech production can inform therapeutic approaches.

6. Investigation on how altered auditory feedback affects speech production in children and adolescents, shedding light on the developmental aspects of speech adaptation.

Incorporating these future directions into research can further our understanding of the complex relationship between altered auditory feedback and speech production, with potential applications in linguistics, communication sciences, and speech therapy.

REFERENCES

Arbabshirani, N., & Shafiei, B. (2014.). Effects of altered auditory feedback on stuttering frequency of people who stutter. *:3rd Neuroscience Congress in Isfahan University of Medical sciences* https://www.researchgate.net/publication/277475970.

Borden, G. J. (1979.). An interpretation of research on feedback interruption in speech. *Brain and Language, 7*, 307-319

Chhangte, L. (2021). The grammar of simple clauses in Mizo. *Papers in Southeast Asian Linguistics No. 11: Southeast Asian Syntax*. https://doi.org/10.15144/PL-A77.93.

Fanai, L. T. (2015). Tones in Mizo language. *Journal of Humanities and Social Sciences, 1*(1), 136-144.

Gogoi, P., Dey, A., Lalhminghlui, W., Sarmah, P., & Prasanna, S. R. M. (2020). Lexical tone recognition in Mizo using acoustic-prosodic features. *12th Conference on Language Resources and Evaluation (LREC 2020), pages 6458–6461*

Govind, D., & Sarmah, P. (2012). Role of pitch slope and duration in synthesized Mizo tones. *Speech Prosody 2012 Sixth International Conference Shanghai* http://www.isca-speech.org/archive.

Hombert, J.-M., Ohala, J. J., & Ewan, W. G. (1979). Phonetic explanations for the development of tones. *Language*, *55*(1), 37. https://doi.org/10.2307/412518.

Houde, J. F., & Jordan, M. I. (2002). Sensorimotor adaptation of speech I: Compensation and adaptation. *Journal of Speech, Language, and Hearing Research*, *45*, 295–310.

House, D. (1996.). Differential perception of tonal contours through the syllable. *4*, 2048-205. 10.1109/ICSLP.1996.607203.

John Marshall Howie. (1976). Acoustical Studies of Mandarin Vowels and Tones (*pp. 138-*

232). Cambridge University press 1976.

Jones, J. A., & Munhall, K. G. (2002). The role of auditory feedback during phonation: Studies of Mandarin tone production. *Journal of Phonetics*, *30*(3), 303–320. https://doi.org/10.1006/JPHO.2001.0160.

Jongman, A., Yue, W., Moore, C. B., & Sereno, J. A. (2005). Perception and production of Mandarin Chinese tones. In E. Bates, L.H. Tan, and O.J.L Tzeng (eds.), *Handbook of Chinese Psycholinguistics*. Cambridge University Press.

Keough, D., Hawco, C., & Jones, J. A. (2013). Auditory-motor adaptation to frequency-altered auditory feedback occurs when participants ignore feedback. *BMC Neuroscience*, *14*. https://doi.org/10.1186/1471-2202-14-25.

Lalhminghlui, W., Terhiija, V., & Sarmah, P. (2019). Vowel-Tone interaction in two Tibeto-Burman languages. *Sixth International Symposium on Tonal Aspects of Languages, Germany* https://doi.org/10.21437/Interspeech.2019-2808.

Morett, L. M. (2019). The Influence of Tonal and Atonal Bilingualism on Children's Lexical and Non-Lexical Tone Perception. *Language and Speech*, *63*(2), 221–241. https://doi.org/10.1177/0023830919834679.

Martine Mazaudon (2009). Number- Building in Tibeto-Burman Languages, Morey, S., Post, M., *North East Indian Linguistics*, *2* (pp. 117-148)

Pike, K. L. (1964). Tone Languages: A technique for determining the number and type of pitch contrasts in a language, with studies in tonemic substitution and fusion. *University of Michigan Press.*

Sarmah, P., & Wiltshire, C. R. (2010). A preliminary acoustic study of Mizo vowels and tones. *Journal of Acoustical Society of India*. 121

Singh, L., & Fu, C. S. L. (2016). A new view of language development: The acquisition of lexical tone. *Child Development*, *87*(3), 834–854. https://doi.org/10.1111/CDEV.12512.

Stuart, A., Kalinowski, J., Rastatter, M. P., & Lynch, K. (2002). Effect of delayed auditory feedback on normal speakers at two speech rates. *The Journal of the Acoustical Society of America*, *111*, 2237–2241. https://doi.org/10.1121/1.1466868.

Teo, A. B. (2020). A phonological and phonetic description of Sumi, a Tibeto-Burman language of Nagaland. *Asia-Pacific Linguistics (pp. 8-10)* https://openresearch-repository.anu.edu.au/handle/1885/12015.

Xu, Y., & Meng, H. (2010). The voice pitch and speed control under frequency modulated auditory feedback conditions in standard Chinese and Japanese speakers. *13th Australasian International Conference on Speech Science and Technology*.

Yip, M. (2002). Tone. *Cambridge University Press*, (pp. 1-16) https://doi.org/10.1017/CBO9781139164559.

Zanini, S., Clarici, A., Fabbro, F., & Bava, A. (1999). Speaking speed effects on Delayed Auditory Feedback disruption of speech fluency. *Perceptual and Motor Skills*, *89*(3), 1095–1109. https://doi.org/10.2466/PMS.1999.89.3F.1095.

Zhiming, B. (2003). Tone. Cambridge University Press. *Phonology*, *20*(2), 275–279. https://doi.org/10.1017/S0952675703004536.