AN ACOUSTIC ANALYSIS OF VOWEL NASALIZATION IN PUNJABI SPEAKERS' PRODUCTION OF ENGLISH IN PAKISTAN

By
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DECLARATION

The work reported in this thesis was carried out by me under the supervision of Dr. Asim Mahmood, Assistant Professor, Department of English Linguistics GC University, Faisalabad, and Prof. Dr. Sarmad Hussain, University of Engineering and Technology, Lahore.

I hereby declare that the title of thesis **"An acoustic study of vowel nasalization in Punjabi speakers' production of English in Pakistan"** and the contents of thesis are the product of my own research and no part has been copied from any published source (except the references, standard mathematical or genetic models /equations /formulas /protocols etc). I further declare that this work has not been submitted for award of any other degree /diploma. The University may take action if the information provided is found inaccurate at any stage.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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ABSTRACT

This study adopted an acoustic approach to find out vowel nasalization patterns in Pakistani English. The present study analyzed Punjabi speakers' production of English words to identify vowel nasalization pattern. As the phonemic inventory, syllable template and the phonotactic constraints of Punjabi and English are different, it was hypothesized that the Pakistani English language users whose L1 is Punjabi apply the Punjabi phonotactic constraints on English which cause differences in coarticulatory process in their L2 production. The presence or absence of nasalization in VN (vowel+ nasal consonant) and NV (nasal consonant+ vowel) contexts, its degree and direction (anticipatory and carryover) were identified, analyzed and explained. For this purpose, five native Punjabi speakers from Lahore were selected for the collection of data. All the participants were advanced users of English. They were asked to pronounce a list of carrier phrases consisting of both Punjabi and English words with different vowels in different contexts. The speech samples were recorded and then analyzed by the speech processing software PRAAT. The results depicted a great degree of nasality for regressive nasalization in both Punjabi and Pakistani English. In English, the speakers showed relatively greater degree of nasality for the /ɪ/ and / æ/ vowels than /ɒ/ and /ʌ/. In Punjabi, the /æ/, /æ̃/, /ɑ/, /ɑ̃/ and /ĩ/ vowels showed relatively more degree of nasality than the others. The short vowel /ʌ/ depicted lesser degree of nasalization both in English and Punjabi. Pakistani English speakers differed from AME in terms of the degree of nasalization for different vowels. Pakistani English speakers showed greater degree of nasality for both low and high vowels while AME prefer low vowels to nasalize greatly. The values A1-P1 and A1-P0 were measured to study the degree of nasalization. The mean of Δ (A1-P1) for Pakistani English speakers was 6 db and the mean of Δ(A1-P0) ranged from 4 db to 6 db. While, for AME, the mean of Δ(A1-P1) ranged from 10 db to 15 db

and Δ (A1-P0) ranged from 6 db to 8 db. The present study also helps to validate the claim that Pakistani English is a separate variety. This study is significant as it may help to identify one of the areas which might result in the difficulty of communication between native and non native users of English.

Chapter One

INTRODUCTION

Nasalization is a very prominent but less understood feature of many languages spoken in Pakistan. This research compared the contextual and contrastive nasalization phenomenon in Punjabi vowels. The contextual nasalization in English vowels produced by Punjabi speakers was also explored. This study also discussed the anticipatory and carryover directions of nasalization in both languages. The degree and direction of nasalization in both languages were determined using acoustic measures. The Punjabi speakers showed the same patterns of nasalization in their L1 (Punjabi) and L2 (English). The results of this study were compared with those of AME speakers to study the similarities and differences between the AME and the English spoken by Punjabi speakers.

1.1. STATEMENT OF THE PROBLEM

The focus of this study was on vowel nasalization in the speech of Punjabi speakers. The nasalization patterns were explored in Punjabi and Pakistani English. Punjabi has an oral-nasal contrast for vowels (Bhatia, 2009) but English language has only oral vowels (Hardcastle & Hewlett, 2006). It was hypothesized that this variation affects the Punjabi native speakers' production of English language.

This study intended to locate the degree and direction of vowel nasalization by using acoustic measures. It aimed to use scientific means to validate its findings and intended to portray them quantitatively. Any determined nasalization patterns of Punjabi were not found, so firstly, the degree and dimension of nasalization were explored in Punjabi and then these results were compared with those of Pakistani English. After determining the nasalization patterns in English produced by Punjabi speakers, the results were compared with those of AME.

1.2. BACKGROUND OF THE STUDY

The use of English language has resulted in gaining the status of global language. English has been recognized as lingua franca. The wide spread of English has caused the emergence of many varieties and dialects all over the world. In Pakistan also, English has been nativized and localized. It has emerged as a different variety like Hong Kong English and Indian English etc. Pakistani people use it with their own patterns and do not follow the native norms. The present study aimed to explore one of the phonological areas of Pakistani English which distinguishes Pakistani English from other varieties of English. So, this study aimed to strengthen the view that Pakistani English is a different variety and also to explore the effect of speakers' L1 (Punjabi) on their production of L2 (English).

1.3. KEY QUESTIONS

This research aims to find answers to the following questions:

1. Do Pakistani English language users nasalize vowel sounds because of the neighboring nasal sounds in VN and NV context?
2. Are some vowels more prone to nasalization than others in Pakistani English?
3. What is the degree of vowel nasalization in Pakistani English?
4. What impact the direction has on nasalization in Pakistani English?

5. What are the differences and similarities in vowel nasalization patterns in AME and Pakistani English variety?
6. What is the direction and degree of nasalization in Punjabi?
7. Do the nasalization patterns of Punjabi affect the nasalization patterns of Pakistani English?

1.4. RESEARCH OBJECTIVES

This study has the following objectives.

- This study aimed to explore the contextual nasalization in Pakistani English.
- This research aimed to find out if some vowels are more prone to nasalization than others in PE.
- It aimed to look at the degree of vowel nasalization in Pakistani English.
- It sought also to explore the impact of direction on nasalization in Pakistani English.
- It also aimed to explore the degree and direction of vowel nasalization in Punjabi.
- It aimed to study the differences and similarities in vowel nasalization patterns in AME and Pakistani English variety.
- This research also aimed to study affect of nasalization patterns of Punjabi on the nasalization patterns of Pakistani English.
- It also aimed to find out the inter-varietal differences in the patterns of vowel nasalization in English and Punjabi.

1.5. NEED AND SIGNIFICANCE OF THE STUDY

The present study sought to identify the nature of vowel nasalization in Pakistani English; it is one of the phonological areas which ELT practitioners should focus while discussing the intelligibility problems. This research intended to explore one of the areas which may contribute for communication challenge between Pakistani English users and the native English speakers. This research is also important as it gives an insight to the language teachers into the nature of phonological patterns that distinguish between Pakistani English and the other varieties of English. This study may also help language teachers in the selection of appropriate teaching methods and strategies that accommodate and highlight the fine distinction of Pakistani English from the other varieties of English. This research is significant as it seeks also to help in determining one of the areas which provide a basis for the validation of the claim that Pakistani English is a separate variety in its own right.

1.6. DELIMITATIONS OF THE STUDY

This research was limited to the study of vowel nasalization in VN (vowel-nasal) and NV (nasal-vowel) contexts only. The number of selected participants was also limited as they were selected from pure Punjabi background and specifically from one dialect. Only the speakers with low F0 were selected, so that the harmonics bearing the nasal effect could be traced accurately. Only four oral vowels of English and four oral and four nasal vowels of Punjabi was selected.

Chapter Two

REVIEW OF LIRERATURE

Vowel nasalization is one aspect of the coarticulation. This chapter commences with the broader phenomenon "coarticulation" leading to the concept of vowel nasalization. Firstly the coarticulatory and assimilatory process are defined and then the articulation and acoustics of nasalization are described. It discusses the relevant studies conducted theoretically or practically to explore nasality phenomenon. The types and directions of nasalization are also discussed.

2.1. COARTICULATION

In connected speech, the physical realizations of sounds are conditioned by segmental context, as sound segments are highly sensitive to context and show significant influence from neighboring segments. Such contextual effect is known as coarticulation (Hardcastle & Hewlett, 2006; Ohman, 1966). Coarticulation is a phenomenon in which the articulatory movements required for one gesture are often anticipated (anticipatory coarticulation) or carried over (carryover coarticulation) during the production of an adjacent gesture (Laver, 1994).

Coarticulation is further divided into the processes of assimilation, dissimilation, reduction and deletion. When a sound is pronounced in connected speech, it may make its neighboring sound more similar, dissimilar, reduced or deleted (Nathan, 2008; Roach, 2001). Similar sounds require less articulatory effort than dissimilar sounds. However, sometimes distinctiveness comes into play, and the speaker is required to make two sounds less similar to one another. So dissimilation is a process by which one segment systematically avoids taking on a feature of a neighboring segment (Zia, 2002).

Coarticulation occurs in particular contexts e.g. vowel to vowel (Cho, 2004; Magen, 1997; Manuel, 1990; Recasens, 2002), vowel to consonant (Recasens, 1984), consonant to consonant (Repp & Mann, 1982) and consonant to vowel (Bradlow, 2002; Chen, Slifka & Stevens, 2007; Li, 2008; Traunmuller, 1999).

There has been no discovered language in which some type or degree of coarticulation is not to be found, leading it to be taken as a universal phenomenon (Farnetani, 1999). But even though it is pervasive, it is also significant as a source of cross-language variation, with different languages showing different patterns and degrees of various types of coarticulation. Ohman (1966) makes clear that languages differ in their coarticulatory patterns. The process of coarticulatory nasalization is an example of coarticulation which is extremely common among languages (Beddor, 1993). However, the degree of nasalization is different among languages, from subtle as in English (Hammond, 1999; Ladefoged, 2010) to strong as in Portuguese (Oliveira & Silva, as cited in Kluge *et al.*, 2009). Beddor and Krakow (1999) have studied this phenomenon and made it clear that English and Thai are the languages which lack oral nasal contrast for vowels, but they differ in the degree to which the vowel preceding a nasal consonant is nasalized.

2.2. Assimilation

When speakers distort distinctiveness for the purpose of articulatory ease, they are usually making the sounds more alike. So, speakers prefer to formulate the easiest sound which most resembles the neighboring sounds. This is a process that makes two or more neighboring segments more similar by making the segments share some feature.

The sounds may be assimilated totally or partially (Raphael, Borden & Harris, 2007) and most of the rules are shared by different languages. They all follow certain phonetic rules but they are also affected by particular phonotactic constraints of that language. So, phonological variations also play their role along with the phonetic rules in speech. (Li, 2008)

2.3. Types of Assimilation

According to Brannan & Weiss (2007), the process of assimilation has two major categories based on the direction in which the features are assimilated to one another. The categories are:

• Progressive Assimilation

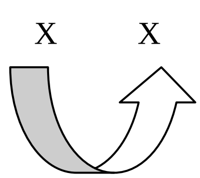
• Regressive Assimilation

2.3.1. Progressive Assimilation

When a sound becomes more like the following sound, this is called progressive assimilation. In English for example:

1. Happen: /hæpn/ ⟶ /hæpm/ (Dretzke, 2008)

Here one sound becomes similar to the preceding sound so it is progressive assimilation. This can be represented as:



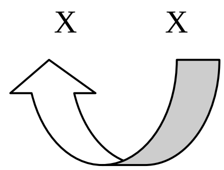
(Progressive Assimilation)

2.3.2. Regressive Assimilation

If a sound changes because of the influence of the following sound, this is called regressive assimilation. In English for example:

2. White pepper: /waɪt pepə/ ⟶ /waɪp pepə/ (Collins & Mees, 2003)

In this example the sound is becoming like the following sound, which is regressive assimilation. It can be represented graphically as:



(Regressive Assimilation)

2.3.3. Bidirectional Assimilation

The assimilation process may sometimes be bidirectional, which is called fusional assimilation but it is not very common. (Jun, 1995)

In Urdu for example:

3. /hɑnknɑ/ ⟶ /hɑ̃ŋkna/ (Zia, 2002)

The vowel is nasalized due to following nasal consonant and /n/ becomes /ŋ/ due to following /k/.

Assimilation can be of manner, place or voicing.

2.3.4. Assimilation of Voicing, Place and Manner of Articulation

The types of assimilation are described on the basis of voicing, place and manner also. Roach (2001) divides assimilation into three types: assimilation of voice, assimilation of place, assimilation of manner. A very common phenomenon in the world's languages is Nasal Place Assimilation (Mohanan, 1993; Jun, 1995; Shin, 2000).The place of articulation of a nasal consonant depends on the place of articulation of the following consonant. There are three nasal phonemes [m, n, ŋ] in English that are all subject to this process. It involves taking the [+nasal] feature on the segment following the vowel and adding or spreading it to the vowel, making the value of [nasal] identical for the two segments. The vowel assimilates to the neighboring nasal consonant (Kluge *et al*., 2009; Mateus & d'Andrade, 2000). This is an example of manner assimilation.

Over different languages, voicing assimilation is very common. For example in English, a consonant [+voiced] becomes voiceless when the preceding consonant is voiceless.

Lapped: / læpd/ ⟶ /læpt/ (Zia, 2002)

Here the consonant (d) becomes (t) when its preceding consonant (p) is voiceless.

2.4. Nasalization

The oral sounds are produced with the complete closure of nasal tract, whereas the nasal sounds are produced with open velopharyngeal port. The phenomenon of vowel nasalization exists in almost all the languages of world (Beddor, 1993). But the level of velopharengeal port's opening is different from language to language and from speaker to speaker.

All the languages over world have oral vowels, but there are some languages which have nasal vowels as well. The nasal vowels are never observed to be greater in number than the oral vowels in any language (Wright, 1986). Different studies have been done on different aspects of vowel nasalization and have explored various patterns of nasalization. These studies are based on acoustics (Chen, 1997, 2007), perception (Beddor, 1993) and physiology (Bell-Berti, 1993; Krakow, 1993).

2.5. TYPES OF NASALIZATION

2.5.1. Contrastive Nasalization

During the production of vowel with neighboring nasal consonants, the languages with contrastive vowels restrict the level of velum lowering and make vowels less nasalized than the languages which lack this oral-nasal contrast. The velum lowering is restricted to maintain oral-nasal contrast and to avoid the contextual nasalization. Herbert (1986) reports that only the languages which have oral- nasal contrast for vowels have this pattern of velum lowering restriction for oral vowels production in context of nasal sounds. Furthermore, Manuel (1990) illustrates that the contrast of nasality in vowels and the degree of coarticulation are correlated inversely.

French is one of the languages which has oral and nasal contrast in their vowel system. This contrast of nasality in vowels has been explored by a number of linguists through using the acoustic and articulatory means (Delvaux, 2002; Delvaux & Soquet, 2001; Delvaux, Metens & Soquet, 2002).

Table.2.1.Words Illustrating Contrasts between Oral and Nasal Vowels in French

ORAL	NASAL	ORAL	NASAL
laid **lɛ** 'ugly'	lin **lɛ̃** 'flax'	leur **lœʀ** 'their'	lundi **lœ̃di** 'Monday'
las **la** 'tired'	lent **lɑ̃** 'slow'	lot **lo** 'prize'	long **lõ** 'long'

Source: From *"Vowels and Consonants"* by Ladefoged & Disner, 2012, Wiley-Blackwell.

In French, the absence or the presence of nasality in vowels changes the meaning of the words. For example, the words "/la/, /lã/" and "/lo/, /lõ/" have different meanings only because of the vowels' oral-nasal contrast. Berger (2007) also states an example of the French words "beau" /bo/ ("beautiful") and "bon" /bõ/ ("good") which contrast by the vowel nasalization. So in

French, the extent of nasalization changes the meaning of the words, leading it to be a language which has phonemically contrastive vowel nasalization.

In French, not all the oral vowels have their nasal counterparts. Klopfenstein (2006) states the example of high vowels /I, y, u/ which do not have the nasal counterparts. A number of studies have explored the French nasalization patterns focusing on the vowels which have oral-nasal contrast (Clumeck, 1976; Cohn, 1993; Rochet and Rochet, 1991). But some linguists also have focused on the vowels which lack this contrast. Spear (2006) has compared the degree of nasalization for the vowel /i/ which has no nasal counterpart. She measures the degree of nasalization for the oral vowels /I, Ɛ/ in context of followed by a nasal consonant and by an oral stop and for the nasal vowel /Ɛ/. To examine the nasalization degree, she measures the bandwidth between the first formant (F1) and second formant (F2). Her study comes with the following results:

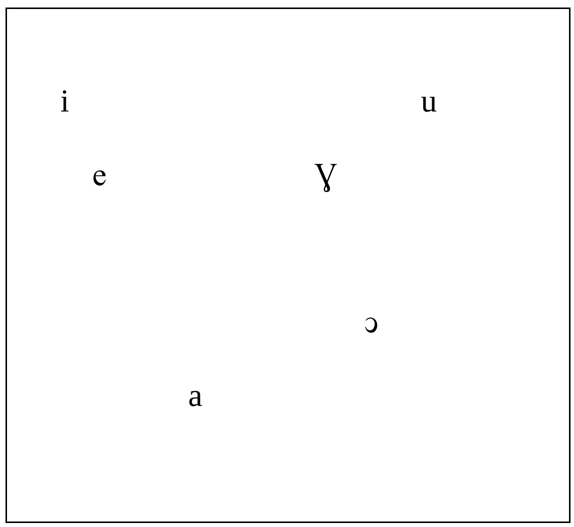
1. /i/+nasal consonant context shows more degree of nasalization in the vowel /i/ than /Ɛ/+nasal consonant context.
2. The duration of nasalization is greater in the /i/+nasal consonant context than the / Ɛ/+nasal consonant context.

These results of Spears' study illustrate a great degree of contextual nasalization in the vowel that do not have nasal counterpart. Hence the vowel / Ɛ/ which has oral-nasal contrast has also some degree of nasalization, indicating that nasalization is not suppressed completely.

Similarly, Delvaux (2002) has measured the degree of nasalization between the French contrastively nasal vowels and the contextually nasalized vowels. She has measured the proportional nasal airflow, during the proportion of all the French vowels before a nasal consonant. Delvaux (2002) reports the results that the degree of nasalization is greater for the vowels which have contrastive nasality than the vowels which adopt nasality from their neighboring nasal consonants.

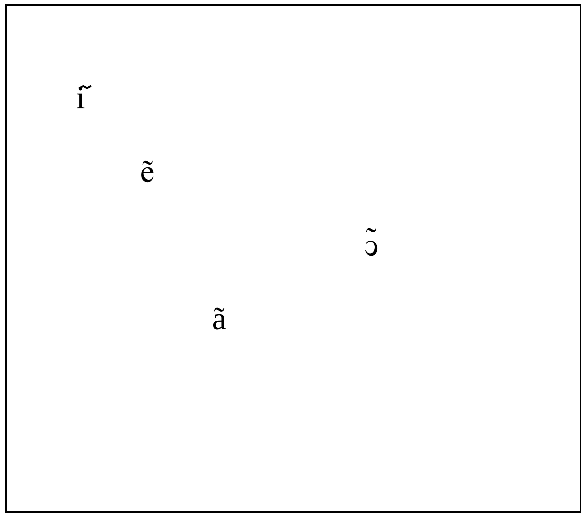
Taiwanese, a dialect of Southern Min, is also one of the languages which have oral-nasal contrast in its vowel system. It has six oral and four nasal vowels. The vowel inventory of Taiwanese is given below:

Figure.2.1. Taiwanese Oral Vowels



Source: From *"Nasal-Oral Contrast and the Degree of Nasalization in Taiwanese*" by Kawasaki, 2006,

Figure.2.2. Taiwanese Nasal Vowels



Source: From *"Nasal-Oral Contrast and the Degree of Nasalization in Taiwanese*" by Kawasaki, 2006,

Taiwanese has words which differ in meaning from each other only because of contrastive nasality. Kawasaki (2006) states an example of the words "/te/ (bag) and /tẽ/ (to pinch)" which have different meanings due to the oral-nasal contrast of vowel. Taiwanese has oral-nasal contrast for vowels, but the phonological environment where this contrast occurs, is limited. In Taiwanese language vowels in CV syllables are either oral or nasal vowel (contrastive). The vowels in NṼ syllable are always nasalized and the oral vowels can never appear in this environment. The vowels in NṼ syllable are always nasalized, while a vowel in VN syllable is always an oral vowel (Chung, 1996; Pan, 2004).

Kawasaki (2006) compares the degree of nasalization among the contrastive vowels (oral-nasal) and the contextually nasalized vowels in Taiwanese. He conducts experiment to judge if the degree of nasalization is greater for the vowels in non contrastive environment than the vowels in contrastive environment. The results confirm that the degree of nasalization for a nasal vowel in CṼ context (where oral-nasal contrast is present) is greater than the vowels in NṼ context (which lacks oral-nasal contrast).

Furthermore Huffman (1987) investigates the timing of contextual nasalization in two West African languages (Akan and Efic), the languages which contrast vowel inventory. Akan is a language which has oral- nasal contrast in its vowel system while Efic lacks this contrast and do not have contrastive nasality. Huffman explores the timing of contextual nasalization and aims to locate the differences in the patterns of contextual nasalization in these two languages. Contextual nasalization of vowels in Akan may be limited in order to preserve phonemic nasality. But in Efic there may be extensive nasalization which begin earlier and end later in vowels because of nasal context.

The results of Huffman's study show the occurrence of nasality effect earlier in the vowels in Aken as compared to the Agwagwune vowels. Huffman claims that the oral/nasal contrast of vowels does not affect the nasalization patterns too much as is generally assumed.

Punjabi language also comes in line with the languages which have oral nasal contrast for vowels. There are ten oral vowels in Punjabi. It has three short / ɪ, ə, ʊ / and seven long / i, e, æ, a, ɔ, o, u / vowels. All these oral vowels have their nasal counterparts as well. (Gill and Gleason, 1969)

2.5.2. Distinctive Nasalization

Other than contrastive nasalization, there are also languages which have contextual vowel nasality. Cohn (1993) reports a greater degree of contextual vowel nasalization before a nasal consonant in English, which lacks a nasality contrast in vowels, than in French, a language with a nasal-oral vowel contrast.

Ladefoget and Disner (2012) describe that the vowel nasalization phenomenon exists in all the dialects of English language. In English, vowels are tended to assimilate with the nasal consonants whenever occur in nasal context. Ladegorget and Disner (2012) illustrate the example of the English word “man”. In such circumstances where a vowel is followed or proceeded by the nasal sound, all the vowels become throughout nasalized. So in English vowels are nasalized because of the phonetic context. Vowels in oral context never adopt nasality feature except in the disordered speech.

Ladefoget and Disner (2012) make comparisons of the spectrums of their own recordings of the words “mean, min, men, man” where the vowels are in oral context with the words “mean, min, men, man” where vowels are in the nasal context. After determining acoustic parameters of nasalization to indicate nasality such as the frequency and the amplitude of the first formant (F1), they report heavy degree of nasalization in the vowels occurred in nasal context.

It is stated that the behavior of the vowels to be nasalized is not similar for all the vowels. Different vowels show different tendencies for the degree of nasalization and the nasality effects are different for all the vowels. They make clear that the presence or the absence of nasality feature in the vowel does not change the meaning of the word in English as compared to the languages such as French. Similarly, Hammond (1999) states that the nasalization phenomenon in English is distinctive as the English language lack minimal pairs for nasal vowels. Rather nasalization in English is context dependent. So in English, the vowels adopt nasality feature under the influence of the following or preceding nasal consonant.

Languages having contextual nasalization or contrastive nasalization or even containing the both types of nasalization differs from each other because of different nasality patterns. There is evidence that the languages which lack oral/nasal contrast for vowels show extensive degree of nasalization. English language is a good example of heavy nasalization of vowels in nasal context.

In contrast, Delvaux et al. (2008) describes that the languages which have oral/nasal contrast for their vowels may limit the degree of contextual vowel nasalization in both high and low vowels, in order to maintain the oral/nasal contrast between vowels. French allows an extensive degree of contextual nasalization for the high oral vowels as all the nasal vowels are mid-low and low vowels in French. So the vowels which have oral and nasal contrast show less degree of nasal coarticulation than the vowels which have no nasal counterpart.

On the other hand, Al-Bamerni (1983) discusses the extensive degree of velopharengeal opening for the high back vowels in Gujarati and Hindi, the languages which have contrastive nasality in their vowel systems. This asymmetry between the degrees of nasalization among various languages suggests that the extent of nasal coarticulation is not dependent on the phonemic inventory of languages. Different languages have different patterns of nasalization for high and low vowels regardless of the presence and absence of oral/nasal contrast for vowels.

2.6. ACOUSTICS OF VOWEL NASALIZATION

The phenomenon of vowel nasalization is very complex to study because of the variation in the exact acoustic characteristics of nasalization among speakers. The acoustic characteristics of nasalization are difficult to examine because of the changes in the anatomical structure of the nasal cavity, vowel quality, and also because of the degree of oral and nasal tract's coupling. (Pruthi *et al*., 2007)

The vowels are nasalized because of the nasal and oral tract's configuration. The level of oral and nasal tract's configuration varies for different degrees of nasalization. The more the velum lowers: the heavier the vowel is nasalized. So, this variation in configuration between oral and nasal tract introduces change in spectrum at transition between the vowel and the nasal consonantal sounds (House, 1957). These acoustic effects are transformed in spectra through introducing nasal poles and zeroes in the region of first formant (F1) and also the shift of vowel formants (especially F1).

Various acoustic effects of vowel nasalization are explored through multidimensional ways. Ladefoged and Maddieson (2012) reports that the vowels which have extra nasality feature are distinguished with reduction in intensity of the first formant (F1) and increase in third formant (F3). This reduction in the intensity is because of the diversion of acoustic energy from the oral cavity to the nasal cavity. There is evidence from the perception based experiments using synthetic stimuli that the reduction in F1 amplitude by 6-8 db is necessary to get a significant level of nasalization perception (House and Stevens, 1956). But later studies do not support this assumption providing the view that the degree of F1 amplitude's lowering is somehow language and speaker specific. As Chen (1997) reports the results of her study on nasalization, the degree of F1's amplitude varies among English speakers and the French speakers. So there is a lack of a fixed measure of F1 amplitude's lowering.

Furthermore, the flattening of spectral region is also studied as an indicator of nasality. Maeda (1982) studies spectral variations in order to investigate the acoustic cues of nasalization. Analyzing 11 French vowels, Maeda reports that the diversion of energy from oral to nasal tract flattens the spectral region between 300 Hz and 2500 Hz. Similarly, Stevens (2000) reports that the widened first formant (F1) and the overall reduced vowel amplitude is the indicator of the presence of nasality feature in a vowel.

Fant (2004) also illustrates that the nasalized vowel has "a distortion superimposed on the vowel spectrum" which is significant by the occurrence of nasal peak in the region of low frequencies (below F1) (p. 156). Similarly, Beddor (1991) describes that the vowels with nasality feature have broader and flatter spectral prominence in the region of low frequency (below F1).

The alterations between vowels and nasal consonants allow coupling to the nasal cavity which shifts the natural frequencies of vowels and comes with additional poles and zeroes (Stevens, 2000). So, the antiformants or nasal zeroes are also observed as an indicator of the energy diversion from oral passage into the nasal cavity (Hayward, 2000).These alterations introduce the shifts of natural velum opening while production. The nasal peaks will be found on an average of around 230-950 Hz (Chen, 1997). The first nasal peak which is observed below the first formant (F1) is of about 230 Hz and the second nasal peak between first and second formant (F1, F2) frequencies is of about 950 Hz.

When the output of nose and mouth is transformed to nose only, for the production of nasal consonant, it causes to produce zeroes. The nasal zeroes are dependent on the level of nasal tract's coupling (Chen, 1997). These zeroes reduce the amplitude of the first and the second formants (F1 and F2) (Mou, 2006). These zeroes are dependent on the level of distance between the opening of velopharyngeal port and the oral constriction. This process will reduce the spectral peak in accordance to the resonance of cavity below the oral closure. (Stevens, 2000)

Chen (1997) has introduced an acoustic approach for the measurement of nasality in her study of nasalized vowels of French and English. She finds the reduction of first formant (F1) as the primary cue of nasalization in vowels and also studies the effect of nasalization on the harmonics in spectrum. She has distinguished nasalized vowels of French and English successfully, employing the two parameters which are A1-P0 and A1-P1. Here A1 is the amplitude of the first formant (F1), P0 is the amplitude of first nasal peak below the first formant (F1) and P1 is the measure of the amplitude of nasal peak between first formant (F1) and the second formant (F2) of the vowel. So, the results of her study confirm that the amplitude of F1 in nasalized vowel reduces relative to its amplitude in oral vowel, and the extra nasality peaks are also noticed.

This measure (A1-P0 and A1-P1) is also been attested by the Pruthi and Espy-Wilson (2007) on several corpus databases. The list of acoustic parameters tested by Pruthi and Espy-Wilson is given below.

Table2.2. A List of Acoustic Correlates of Nasalization and the APs used to Acquire them

Acoustic Correlate	**Proposed Aps**
Extra peaks at low frequencies and the relative amplitudes of these peaks as compared to the first formant amplitude	• $sgA1-P0$, where $A1$ is the amplitude of the first formant, and $P0$ is the amplitude of an extra peak below $F1$. The prefix *sg* implies that a combination of cepstrally smoothed spectra (*s*) and group delay spectra (*g*) was used to find the exact location of the extra peaks. $F1$ was obtained by using the ESPS formant tracker [Talkin, 1987]. • $sgA1 - P1$, where $P1$ is the amplitude of an extra peak above $F1$. The APs, $sgA1 - P0$ and $sgA1 - P1$ are automatically extractable versions of the APs proposed by [Chen, 1997]. • $sgF1 - FP0$, where $FP0$ is the frequency of the extra peak below $F1$. • $teF\ 1$, correlation between the teager energy profile [Caims, 1996] of speech passed through a narrowband filter (bandwidth = 100 Hz) and a wideband filter (bandwidth = 1000 Hz) centered around $F1$.

Extra peaks across the spectrum	• $nPeaks40dB$ counts the number of peaks within 40dB of the maximum dB amplitude in a frame of the spectrum.
Reduction in $F1$ amplitude	• $a1 - h1max800$ is the difference between $A1$ and the amplitude of the first harmonic ($H1$). The value of $A1$ was estimated by using the maximum value in 0-800 Hz. • $a1 - h1fmt$ is the same as the previous AP except that $A1$ is now estimated by using the amplitude of the peak closest to $F1$ obtained by using the ESPS formant tracker. The APs $a1 - h1max800$ and $a1 - h1fmt$ are automatically extractable versions of the $A1 - H1$ parameter proposed by [Huffman, 1990].
Increase in $F1$ bandwidth	• $F1BW$ is the bandwidth of $F1$.
Spectral flattening at low frequencies	• $std0 - 1K$ is the standard deviation around the center of mass in 0-1000 Hz. This AP not only captures the spectral flatness in 0-1KHz, but also captures the effects of the increase in $F1$ bandwidth and the reduction in $F1$ amplitude. This AP was proposed by [Glass, 1985].

Source: From *"Acoustic Parameters for the Automatic Detection of Vowel Nasalization*" by Pruthi & Espay-Wilson, 2007,

They achieved a satisfactory accuracy rate on each database. Among those results, 96.28% is the highest rate.

The differences in the cross-sectional area of the velopharyngeal port and in the timing of soft palate's raising and lowering, cause differences into the acoustic demonstration of nasality. Furthermore, speakers also differ in the properties of their vocal tracts. They can also manipulate other factors, such as to spread their glottis allowing more coupling between the sub-glottal system and the rest of the nasal system, to further lower the second formant's amplitude at the nasal landmark, which has been considered one of the acoustic correlates of nasalization.(Mou, 2006)

There are many studies which compare the timing and extent of coarticulatory nasalization between different languages. Sole (1992, 1995) states that the velum lowered earlier in vowels following nasal consonant in American English than in Spanish. She also claims that this lowering of velum will be for a greater portion of vowel in American English than in Spanish. Cohn (1990), Rochet and Rochet (1991) also have explored the same difference in timing of nasalization between American English and French.

Furthermore, Huffman (1989) investigates the time course of nasalization in English language. He studies spectral differences between contextually nasalized and oral vowels. In the analysis of data, nasal poles are traced in the 600 to 1000 Hz frequency range and nasal zeroes are in 200 to 300 Hz or even above it. The measured time of nasality feature in vowel indicates that the nasal pole occurs 40 – 50 ms after onset of the vowel or sometimes earlier than this, and moves up throughout the contextually nasalized vowels.

2.7. PHONETIC CONTEXT AND NASALIZATION

Phonetic context is one of the major factors on which the spatial and temporal degree of vowel nasalization depends. For example, there will be more extensive coarticulatory nasalization when the vowel is followed by a nasal and then voiceless oral consonant (VNC) than is followed by a nasal and then the voiced oral consonant (VNC) (Malecot, 1960). Moreover, the vowel will also be more extensively nasalized when it is followed by a nasal and then the fricative (Ohala and Busa, 1995).

2.8. PROSODIC STRUCTURES AND NASALIZATION

The degree of vowel nasalization varies because of the prosodic influences also. For example, the tautosyllabic VN sounds exhibit more nasalization than the hetrosyllabic sequences (Cohn, 1990; Sole, 1995).

Stress also plays very important role in this regard. The vowels in stressed syllables are more extensively nasalized than in unstressed ones (Schour-up, 1972; Vaissiere, 1988). Krakow (1993) measures the difference of the degree of nasalization in vowels occurred in nasal environment. Krakow, conducting his research on American speakers, finds articulatory evidence for Schourup's claim. He studies the role of stress in the spatial and temporal patterns of the velic lowering and raising for different sounds. While doing this, it is noticed that American speakers make different stress patterns for the given syllable types (/mv´bvb/ Vs /mvbv´b/; /bv´bvm/ Vs /bvbv´m/). The velic movement for each vowel following or proceeding /m/ is measured to look at stress affects.

The results of Krakow's study indicate that the height of velum is lower for the stressed vowels adjacent to the nasal consonant /m/. This pattern of velum gestures due to stress reflects changes in temporal extent of velum movements rather than the spatial differences of the velic lowering for the nasal consonant. Krakow states an example that "the velic lowering gestures for the initial /m/ in /ma´bab/ and /maba´b/ appeared quite similar both in their timing and spatial extent, but velic raising from the low position was initiated considerably later in /ma´bab/ than

/maba´b/”. So, the findings of krakow’s study indicate that the velum lowers at greater degree for stressed syllables allowing them to be nasalized more extensively than the unstressed ones.

2.9. VOWEL QUALITY AND NASALIZATION

The extent of vowel nasalization varies depending on vowel quality, type and duration also. For example, in nasal context, long vowels are more tended to be nasalized than the short vowels (Whalen and Beddor, 1989). Moreover, the lower vowels are more prone to nasalization than high vowels (Bell-Berti, 1993).

In Mandarin VN syllables, Chen (2000) finds that the degree of nasalization varies with the height of the vowel. Specifically, the low vowels are tended to have larger, slow and a longer phase of nasalization as compared to the high vowels. In the same way, Lin (2007) provides the evidence from his study on loan transitions of the English names (“Tom” and “Tim”) in Chinese language as /taŋ.mu/ and /ti.mu/. In Chinese word /taŋ.mu/, the extra /ŋ/ has replaced /ɑm/ in the English word “Tom”, but there is no extra nasal used to substitute /ɪm/ in the word “Tim”. On this basis, Lin suggests that the vowel /ɑ/ which is a low vowel is perceived longer and more nasalized than /ɪ/ which is the high vowel.

Bell- Berti (1993) states that in English, low vowels are more prone to nasalization. Similarly, Krakow (1993) illustrates the nasalization pattern in the native Speakers’ production of English. The results show that low vowels are more intended to be nasalized than the high vowels. Furthermore the results of Kluge’s study are consistent with this preference of low vowels to be nasalized extensively. Kluge (2004) investigates the effect of four vowels /ɪ/, /æ/, /ʌ/, /i/ on the production of nasal consonants in mono or disyllabic syllables’ final position. The findings of her study indicate a great degree of nasalization in low vowels among the four vowels.

Chen (1975) states the nasalization for high and low vowels in different dialects of Chinese language. She reports a higher degree of nasalization in the low vowels rather than the mid or high vowels. Hajek (1997) describes the low vowels' tendency to be nasalized heavily than the mid and high vowels in Northern Italy.

But there are also a number of studies which proposes greater degree of nasalization in high vowels as compared to the low vowels. Rochet and Rochet (1991) study nasalization in Canadian French and English. The results of their study demonstrate that contextual nasalization in high vowels has a higher level and a longer duration of nasality as compared to the low vowels.

Delvaux (2008) studies the nasal coarticulatory effect on both high and low vowels in French and aims to find out some patterns of vowel nasalization phenomenon. The findings of Delvaux's study come in line with the Rochert and Rochert (1991) as they also report extensive carryover nasalization in the high vowels than the low vowels. Hu (2005) reports the case of nasalization in Ningbo Chinese. The results of his study show the degree of nasality in three nasalized vowels : / ã/, /ɔ̃/, /ĩ/. His findings indicate that the high vowel /ĩ/ in Ningbo , has extensive nasalization than the other two vowels (/ã/, /ɔ̃/). So, Fang's study comes in line with the claim that high vowels are more prone to nasalization.

Nasalization also introduces some change in the vowel height for phonemic nasal vowels in a number of languages. The vowels are intended to be centralized under the effect of nasalization. High vowels become lower and the low vowels become higher (Beddor, 1986). There are also a number of studies on American English which confirms that the high vowels are tended to be low because of the nasalization influence **(**Beddor, *et al*. 1986; Krakow, *et al*. 1988; Macmillan *et al*. 1999)

So, languages differ on the basis of nasalization patterns. There is cross linguistic evidence that some languages favor extensive nasalization for the high vowels than low vowels. But there are also languages which prefer to nasalize low vowels as compared to high vowels. Hence, Hajek and Maeda (2000) conclude that low vowels are nasalized extensively in some languages and the high vowels in others.

2.10. ANTICIPATORY Vs CARRYOVER NASALIZATION

There is evidence that nasalization can take place in both carryover and anticipatory directions. Different languages show different tendencies regarding the directions of nasalization. So, the phenomenon of anticipatory and preservative nasalization differs from language to language.

Delvaux (2008)reports that French favors the carryover nasalization than anticipatory nasalization. As the results of his study show that in the vowels before nasal consonant (VN) the "nasal airflow onset is either synchronous with oral closure or anticipated through about 25% of the vowel duration whereas in NV items, nasal airflow remains above zero level through 80% or more of the vowel" (P. 596). Similarly in CṼ tokens, only some stops, fricatives and liquids favor anticipatory nasalization, nasal airflow begins in last 25% or even later of the consonant. In most of the stops, nasality is even delayed. In contrast, all the oral consonants occurring before nasal vowel are prone to nasalization without any exception.

Basset *et al.* (2001) also compare the degree of the anticipatory and carryover phenomenon in the velum behavior during the spontaneous speech production and also compare the results with the same read speech data in French. They observe a significant difference between the directions of nasalization in French. Their results are consistent with that of Delvaux (2008) indicating the preference for preservative nasalization in French.

In the same way, Rossato *et al*. (2003) while measuring the velum height for contextual and contrastive nasalization phenomenon, confirms the extensive amount of preservative nasalization in French than the anticipatory nasalization. Hence, there are a number of other studies also which supports the asymmetry between the regressive and preservative nasalization in French (Cohn, 1990).

In contrast, Bell- Berti (1993) reports that the vowels become nasalized more often in the contexts of VN (anticipatory context) rather than in NV context (carryover contexts). Krakow (1993) states that the vowel nasalization occurs in pre-nasal positions more frequently and for a longer duration than in post-nasal positions. English language shows extensive nasalization in regressive direction (Chen 2007). The Akan language is observed to consist of both carryover and anticipatory contextual nasalization while Agwagwune has strong carryover coarticulation and a less degree of coarticulation in anticipatory direction (Huffman, 1987).

2.11. DISORDERED SPEECH AND NASALIZATION

Bell- Berti (1980)reports that the ability of speakers to control the coupling between nasal tract and the oral tract is crucial for the production of normal speech. There are several reasons of configuration between nasal tract and the vocal tract. This configuration may also be due to the anatomical or functional problems (Stevens et al., 1986). For example cleft palate patients have hyper nasality due to the velopharyngeal insufficiencies. Inadvertent nasalization is another example of speech disorder which causes the velopharyngeal port to be opened excessively in vowel production. This is a very common problem of deaf speakers (Stevens et al., 1976; Chen, 1995).

These types of speech disorders are because of the speakers' inability to decouple the nasal cavity from the oral cavity. Speakers' inability to decouple nasal and oral tract results into the nasalization or the hyper nasality which transfers the feature of nasality into the purely oral sounds. So, the people with such speech disorders are even disable to produce oral sounds because of a continuous coupling between oral and nasal cavities.

Therefore nasalization in the speech of hearing impaired children is one of the types of deviation from normal individuals which is discussed by Chen *et al* (2000). Chen (1995) reports that inadvertent nasalization is one of the abnormalities that cause intelligibility problem for hearing impaired individuals' speech. She analyses the speech of hearing impaired children and compares the results with the nasalization of vowels in the speech of normal hearing individuals. For this, two professional phoneticians have judged the hearing impaired children's vowels and these judgments are performed on a scale of 1 – 9, on which the greater degree of nasality is indicated by a high score. The average judgments for the normal hearing individuals are 2 – 3 on the scale, while the hearing impaired individuals receive a wider range of average judgments ranging from 3.5 to 8.

Chen also measures A1-P1 from the spectra every 10 ms and these measures (A1-P1) are averaged throughout the duration of a vowel. The analysis of data shows a great degree of nasalization in the speech of hearing impaired children than that of the normal hearing individuals. The measurement of A1- P1 is about 10 db or even greater for the normal hearing persons, while this measure is very low which is about 2 db for the normal hearing persons. So the findings of Chen's study confirm that the persons with hearing impairments have a greater degree of nasality as compared to the normal hearing speakers.

Stevens (1960) analyses the nasalized vowels in the frequency domain implying an analysis- by- synthesis technique. This analysis-by- synthesis technique enables to determine the range for the values of parameters related to nasalization. Stevens implements this technique for vowels produced by the hearing impaired children. As they are considered the persons showing highly significant degree of nasality, which normal hearing speakers can never make. So, the values taken from the speech of hearing impaired speakers are measured to obtain the extreme values for nasality. These extreme values can possibly not be taken by the normal hearing speakers, as they make narrower range of nasalization as compared to the hearing impaired speakers. Hence Steven's study of excessively nasalized vowels of hearing impaired speakers allows to determining the range of the first formant bandwidth and also the frequency separation for nasalized vowels between their nasal poles and zeroes (Fant, 1960; Stevens, 2000).

Furthermore, surgery for the Sinusits, the paranasal sinuses' inflammation, also affects the production of nasal sounds. Most of this surgery "is intended to enhance ventilation of the paranasal sinuses, and this enhanced ventilation is achieved by the removal of obstructing bone and soft tissue with enlargement of the sinus drainage openings" (Chen *et al*, 2000, P.307). This change in the nasal anatomy introduces variation in the acoustic and perceptual characteristics of nasal sounds.

Chen and Metson (1997) study the effects of sinus surgery on the speech spectra of patients' nasal production. They identified the effect of these anatomical deviations on the perception and the acoustic characteristics of nasal sounds. For this, they analyze the speech of five patients (three male and two female), who are the native speakers of English language. The speech is recorded from the speakers one week before, after one week and one month after the surgery. The speakers produce utterances with the vowels in both oral and nasal contexts. The spectral analysis of the nasal sounds /m/ and /n/ before and after the surgery indicate a clear difference of values.

The analysis of the data after surgery shows significant increase in the amplitude of F1 (A1), and decrease in the amplitude of nasal peak (P1). For all of the patients, the averages of $(A1\text{-}P1)_N$ after surgery has increased which depicts the less degree of nasality. The average $(A1\text{-}P1)_N$ ranges from 11db to 23db for the nasal sounds produced after one month of surgery. In the same way, Chen and Metson (1997) also analyze the vowel sounds recorded from the patients before and after their surgery. The acoustic measures (A1-P1, A1-P0) taken at the beginning and ending of the vowels in both nasal and non-nasal contexts show significant differences in the degree of nasality. The average A1-P1 if vowels in nasal context, increases by 10 db to 15db after the surgery (more than one month), as compared to the measures taken before surgery. The average A1-P0, after surgery, decreases by 4 db to 7db.

The acoustic measures (A1-P1, A1-P0) for the vowels in non-nasal context do not show statistically significant differences after and before the surgery. So the analysis of nasal consonants and the nasalized vowels of patients before and after surgery depict that the degree of nasality decreases after the surgery which is logically because of the change in the nasal anatomy.

As hearing impairedness is considered one of the causes of hypernasality in speakers. Cochlear implantation is used to remove this impairedness. In the way, Hassan *et al.* (2011) study the influence of cochlear implantation on the nasalance feature of speech in Saudi adults who are post-lingually hearing impaired. They find a statistically significant difference between the pre and post implantation nasalance values and come with the conclusion that hearing impairedness causes hypernasality that can be controlled by proper treatment.

2.12. WORLD ENGLISHES

This research comes within the framework of world Englishes. English language has gained the status of lingua franca and has been recognized as a global language (Crystal, 2004). It has been nativised in various countries and has resulted in the emergence of new varieties and dialects (Boltan, 2004). Because of this wide spread of English, various terminologies come into play. For example "Englishes", "global language" etc and all these terminologies have different philosophies behind them.

Different scholars have presented different models of English. Almost at the same time, three models regarding English varieties have been introduced by three scholars aiming to characterize English varieties into a conceptual set. Kachru (1982) proposes a model of World Englishes which is accepted globally. Kachru (1982) divides English speaking native and non-native countries into three umbrella labels: the inner circle, the outer circle and the expanding circle. These three circles "represent the types of spread, the patterns of acquisition and the functional allocation of English in diverse cultural contexts." (Jenkins, 2003, P. 18). Kachru's circular model is based on the "historical context of English, the status of the language, its geographical distribution and its functions in various regions" (Mohammed, 2010).

He classifies the UK, USA, Canada, Australia, New Zealand, etc into the inner circle. The inner circle represents the countries where English is the primary language. It comprises the native speakers of English whose mother tongue is English. The outer circle includes Bangladesh, India, Pakistan, Malaysia, Singapore etc. It represents the spread of English in the non-native contexts. The outer circle includes the countries where English has become part of the chief institutions of the countries and plays its role as a second language in multilingual settings.

The expanding or the extending circle of the model includes China, Egypt, Indonesia, Israel, Japan, Korea etc where English is enjoying the status of international language. Although the expanding circle countries do not have colonized by the inner circle countries and even they do not have given English the administrative role, rather English is serving as international language in these countries. As the name of this circle suggests, it gradually includes more and more countries in its origin. Hence, in these countries English is taught as foreign language.

In the same way, Jenkins (2003) divides English speaking countries into two Diasporas on the basses of native and non-nativeness. The first Diaspora includes native English varieties and the second Diaspora consists of the non-native varieties. The first Diaspora includes the new mother tongue varieties of English e.g. American English, Australian English etc. while the second Diaspora includes the “new Englishes” where English is not the mother tongue of the speakers, rather is used as a second language. This Diaspora of non natives includes Asian and African countries.

Jenkins states that the English language in these Diasporas differs because of accent, vocabulary, grammar, discourse strategies.

Furthermore, Jenkins (2003) divides the English language as spoken in Asian countries into two categories. First category includes the Asian countries where English has been institutionalized and the other consists of the countries where it is not the part of the institutions of the countries.

Institutionalized varieties (Outer circle)	non-institutionalized varieties (Expanding circle)
Bangladesh	Cambodia

Bhutan	China
Brunei	Indonesia
Fiji	Japan
Hong Kong	Korea
India	Laos
Malaysia	Maldives
Nepal	Myanmar
Pakistan	Taiwan
Philippines	Thailand
Singapore	Vietnam
Sri Lanka	

Boltan (2008) states that 18 million people in Pakistan are English users which make Pakistan the third largest English using Asian country (as cited in Raza, 2008).

2.13. PAKISTANI ENGLISH

Different studies have discussed the idiosyncrasies of Pakistani English which distinguish it from the other varieties of English. Mahboob and Ahmar (2004) have explored some features of Pakistani English such as phonology, grammar, lexis and syntax. Moreover, Raza (2008) has discussed a variety of distinct phonological features of Pakistani English such as rhoticity and epenthesis etc. Raza's study comes in line with the claim that the reason of all these differences is the mother tongue influence in Pakistani English language users' speech.

Hickey (2004) discusses Pakistani English as sharing the characteristics of South Asian Englishes. Raza (2008), Kachru and Smith (2008) also support Hickey (2004) concerning the general characteristics of South Asian Englishes. South Asia consists of about a fifth of the world's residents. In South Asian region, several varieties of English language have emerged. It includes the English spoken in Pakistan, India, Bangladesh, Sri Lanka, Nepal and Bhutan (Crystal, 2004). Some of the phonological features of Pakistani English are described below. These features demonstrate the variations of Pakistani English from the other varieties of English.

- Rhoticity

Pakistani English is a rhotic variety of English (Mahboob, 2004). Pakistani speakers pronounce rhotic /r/. Rahman (1990) states that the degree of rhoticity in Pakistan depends on the sociolinguistic factors. Acording to him, the Pakistani speakers of acrolectal variety of Pakistani English may not pronouunce /r/ in the postvocalic position. But the speakers of mesolectal and basilectal varieties of Pakistani English are rhotic. They pronounce /r/ in all the contexts.

- Retroflexion of /t/ and /d/

The retroflexion of /t/ and /d/ is also one of the features which make Pakistani English distinct from RP. The Pakistani English speakers pronounce retroflex stops instead of RP alveolar stops. Mahboob (2004) states the examples of these retroflex stops in the words "strut" /ɪsʈrʌʈ/ and "dress" /ɖres/. Kachru (1992) lists this tendency of pronouncing the RP alveolar stops with retroflexion as one of the features of Asian languages.

- Dentalization /t̪/ and /d̪/

Pakistani English speakers pronounce dental stops instead of the RP dental fricative . Mahboob (2004) states the examples of this change in manner of articulation as in the words "north" /nɔːr t̪/ and "then" /d̪en/. This phenomenon of dentalization of RP fricatives is also listed as one of the features of South Asian Englishes (Kachru, 1992).

- /v/ and /w/

Pakistani English speakers do not make distinction between /v/ and /w/. The two sounds /v/ and /w/ are pronounced as allophones of /w/ (Mahboob, 2004). Acording to Mahboob (2004), there may be the reason that the indegenous languages of Pakistan (e.g. Urdu and Pashto) do not have phonemic distinction between these two sounds. Rahman (1990) makes clear that because Pashto does not have phonemic distinction between /w/ and /v/ so the Pashto speakers do not distinguish these two in English as well. Kachru (1992) describes this as a feature of South Asian Englishes.

- Clear /l/

RP makes a clear distinction between the clear /l/ and dark /l/. But Pakistani English speakers pronounce only clear /l/ (Mahboob, 2004). Mahboob (2004) describes the example words "goal" /go:l/ and "lot" /lɔ:ʈ/. Pakistani English speakers do not make allophonic distinction between these two. This feature is also stated as distributing to the effect of Urdu language on English. As Urdu is a language which does not have allophonic variation between dark /l/ and clear /l/. Kachru states this phenomenon as another feature of South Asian languages (1992).

- Epenthesis

Rahman (1990) states that the Punjabi speakers of Pakistani English insert an epenthetic vowel /ə/ between the sibilant and the stop. Mahboob (2004) also describes that Pakistani English speakers break consonant clusters by inserting vowel between them.

The present study intends to explore one of the phonological features of Pakistani English. This study aims to look at vowel nasalization phenomenon in Pakistani English and Punjabi languages.

2.14. L1 INFLUENCE ON L2

It is usually believed that people's perceptions are language specific and that they perceive L2 segments through the filter of their L1 sound system (Best, Mcroberts & Goodell, 2001; Best & Tyler, 2007; Harnsberger, 2001). Flege (1995) argues that L2 speakers may interpret L2 sounds through the grid of their L1. This "ensures that nonnative speakers will perceive at least some L2 vowels and consonants differently than do native speakers" (Flege, 1995, p. 237). The relationship between L1 and L2 plays a very important role in the perception and production of second language sounds (Flege, 1995).

Consideration of the differences in the way the word-final nasal consonants are pronounced in English and Brazilian Portuguese is very important to the understanding of the difficulties that the Brazilian learners of English may find in the identification of English word-final nasal consonants /m/ and /n/ (Kluge, 2010, Kluge et al., 2007). Similar differences are found by Aoyama (2003) in English nasal perception by Korean and Japanese speakers. Anoyama states that Japanese speakers classify /n/ - /ŋ/ as uncategorizable since their L1 does not distinguish the two. So the relationship between L1 and L2 segments plays an important role in the perception and production of L2 segments.

The present study intends to see the nasalization patterns in Punjabi at first. Then it owes to study nasalization patterns in the Punjabi speakers production of English. This study intends to portray the similarities and differences between the speakers' production of L1 (Punjabi) and L2 (English).

Chapter Three

METHODS AND MATERIALS

This study intends to locate the degree and direction of vowel nasalization by using acoustic measures. It aims to use scientific means to validate its findings and intended to portray them quantitatively. This chapter explains the detail of data set, speakers and the analysis techniques used for this study.

3.1. STIMULI

The stimuli used for this study consisted of two types of data set. One consisted of English words and the other contained the data of Punjabi words.

3.1.1. English data set

For English data, four vowels /ɪ, æ, ɒ, ʌ/ of English were used to study the nasalization phenomenon. Each of these vowels was put in CVN, NVC, CVC contexts. Where C stood for oral consonants (oral stops), N referred to the nasal consonants / n, m, ŋ / and V referred to the vowels. Those vowels were selected for this study, which occur in all these contexts (CVN, VCN and CVC) in English. The vowels were studied first in oral context (CVC) and then were compared for nasality effect in nasal contexts (CVN, NVC). So, the contextual nasalization was intended to be studied in English language. The selected vowels in oral contexts are given below (see 1).

(1)

Bag /bæg/

Bob	/bɒb/
Cup	/kʌp/
Bid	/bɪd/

All these four vowels were analyzed in nasal contexts as well. Each of these was held in two nasal contexts. In CVN context, the vowels followed the nasal consonant / n, m, ŋ / where the regressive nasalization was studied. The list of words in each context is given in data set (2).

(2)

Ban	/bæn/	Dam	/dæm/	Bang	/bæŋ/
Con	/cɒn/	Tom	/tɒm/	Bong	/bɒŋ/
Pun	/pʌn/	Gum	/gʌm/	Bung	/bʌŋ/
Bin	/bɪn/	Dim	/dɪm/	King	/kɪŋ/

In the second nasal context, vowels were in NVC context i.e. the vowels were preceding the nasal consonants. So, in NVC context, the degree of progressive nasalization was studied. The list of words is stated in data set (3).

(3)

Nab	/næb/	map	/mæp/
Knob	/nɒb/	mop	/mɒp/
Nut	/nʌt/	mud	/mʌd/

Nib /nɪb/ mid /mɪd/

All the words consisted of single syllable. The reason for choosing the mono syllabic words was to avoid the effect of coarticulation across syllable boundaries. Each of these words was embedded in a carrier phrase for recording:

I said …………loudly.

"/aɪ sed ……. laudli/".

So, the target words were with the consistent pattern of stress in sentence.

3.1.2. Punjabi data set

The Punjabi data contained of four vowels / æ, a, ʌ, ɪ /. Only those Punjabi vowels were selected which are close in terms of articulation to the four English vowels used for this study. The Punjabi words were either monosyllable or disyllables. Where it was not possible to find the vowel in a particular context in single syllable word, two syllable word was selected. In Punjabi data set, the oral consonants at the onset or offset of the syllables were not always the stop consonant as compared to English data set. The reason for taking the two syllables and the oral consonants other than stops was the difficulty to find the Punjabi vowels in the contexts similar to that of English used for this study. These four Punjabi vowels were held in four contexts (oral vowels, nasal vowels, vowels preceding nasal consonants and vowels following nasal consonants). The data set for vowels in oral context is given in data set (4).

(4)

غیب /ɣæb/

پاک	/pak/
کَٹ	/kʌt/
پِٹ	/pɪt/

Moreover, these four vowels were analysed in two CVN and NVC contexts to study the contextual nasalization. The vowels following nasal consonants (VN) were selected to study regressive nasalization in Punjabi (see (5).

(5)

بھین	/bæn/	قیم	/qæm/	بھینگا	/b^{h}æŋə/
پان	/pan/	شام	/ʃam/	تانگ	/taŋ/
کَن	/kʌn/	کَم	/kʌm/	جَنگ	/ʌŋ/
دِن	/dɪn/	نِم	/nɪm/	ڈِنگ	/dɪŋ/

In the second type of syllables, the vowels in nasal contexts were used to analyze preservative nasality in Punjabi language. In this case the vowel preceded the nasal consonant. The words used to study presevative nasalization are stated in data set (6).

(6)

نیر	/nær/	میل	/mæl/
ناپ	/nap/	ماپ	/map/

نَگ	/nʌg/	مَت	/mʌt/
نِب	/nɪb/	مِٹ	/mɪ t̪/

Punjabi is one of those languages which offer the oral and nasal contrast in vowels. So the nasal counterparts of the four oral vowels were included in data set to study the contrastive nasality. Data sat (7) shows the selected nasal vowels.

(7)

پینداں /pæ˜da/

بانگ /bɑ̃g/

کنب /kʌ̃b/

پِنڈ /pĩd/

So, the degree of nasalization was determined and compared in the contrastively nasal and contextually nasalized vowels of Punjabi language. All these Punjabi words were embedded in a carrier phrase:

"میں ------------ کیا"

"mæn……….. kea"

"I said…………......"

3.2. RESPONDENTS

For this study, the participants with low fundamental frequency were selected, so that the harmonics showing nasality effect could be traced in spectrum accurately. Therefore, male participants were selected for this study. Their fundamental frequency ranged from 100 to 150 Hz. Five educated users of English with Punjabi L1 participated for the present study. Five speakers were used to record English data and four of them were used to record Punjabi data.

All the speakers were from one dialect of Punjabi which is Majhi dialect. A questionnaire was used to determine the dialect of speakers. All the five respondents belonged to Lahore, Punjab. They all use Punjabi language in their daily life. The age of respondents ranged from 20 to 35 years.

3.3. DATA COLLECTION

All the words (both Punjabi and English), embedded in carrier phrases were written on cards and given to the respondents for recording. The cards were shuffled after each recording. Five repetitions of each data set were recorded from each speaker. The data was recorded with five repetitions of each token from each respondent. So, a total of 1160 utterances have been recorded and analyzed.

- English data = 5 speakers * 5 repetitions * 6 templates * 4 vowels (600)
- Punjabi data = 4 speakers * 5 repetitions * 7 templates * 4 vowels (560)

Before getting recordings from the speakers, they all were provided the data cards, so that they could read the sentences at first and make themselves familiar with the utterances. This activity was done to minimize the chance of error in the pronunciation of sentences. Then they were instructed to pronounce the sentences with their normal speech rate (neither too fast and nor too slow). They were also asked to scratch the card only after pronouncing each utterance completely, so that the noise of scratching cards could be avoided. There was also a proper distance maintained between the mouth of the respondent and the mic. The Logitech USB Microphone was used for recording data

3.4. ANALYSIS

The vowels were analyzed by studying the spectrum. For this purpose the software PTAAT was used. Each vowel was studied at three points: initial, middle and final. The formant values were measured at these locations to study the differences in vowel portions.

The measurements at medial position were taken by placing the mark at the middle point of the vowel's total duration. The measurements at initial point were taken not at start of the vowel. The very initial and the very last harmonics in the spectrum were not taken into consideration for analysis because they were completely suppressed due to the effect of neighboring sounds. So the measurements were taken at initial point after skipping initial harmonics in the spectrum. The same was done for the readings taken at the end of the vowel. The measurements were taken after leaving some harmonics at the end of the vowel spectrum.

3.5. MEASUREMENTS

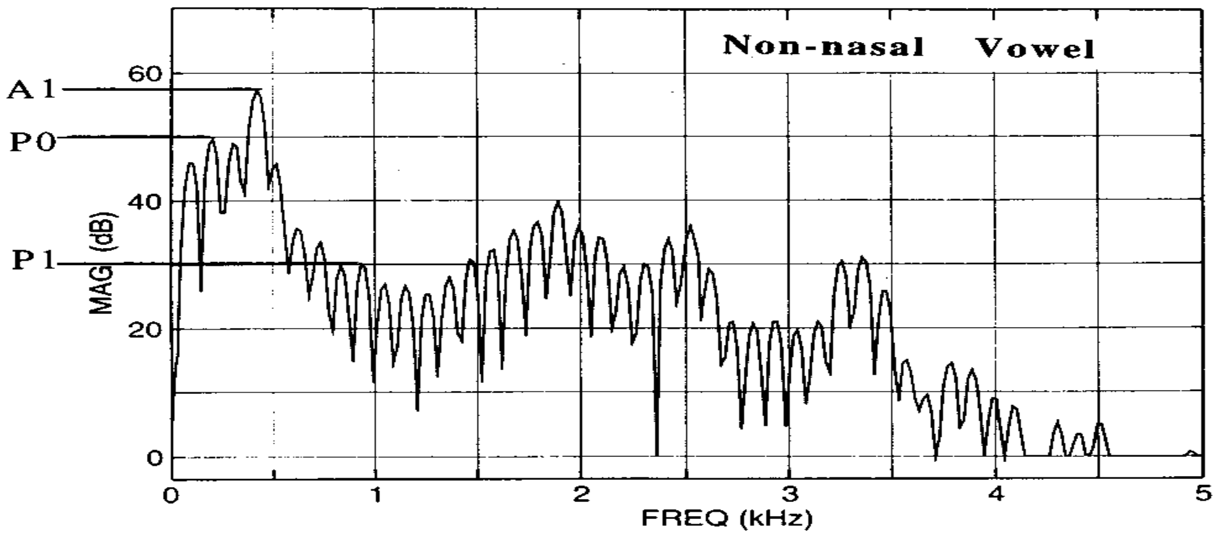
For this study, the methodology introduced by chen (1997) was adopted. Chen introduced an acoustic approach for the measurement of nasality in her study of nasalized vowels of French and English. She distinguished nasalized vowels of French and English successfully, employing two parameters i.e. A1-P0 and A1-P1.

- A1 is the amplitude of the first formant (F1),
- P0 is the amplitude of first nasal peak below the first formant (F1) and
- P1 is the measure of the amplitude of nasal peak between first formant (F1) and the second formant (F2) of the vowel.

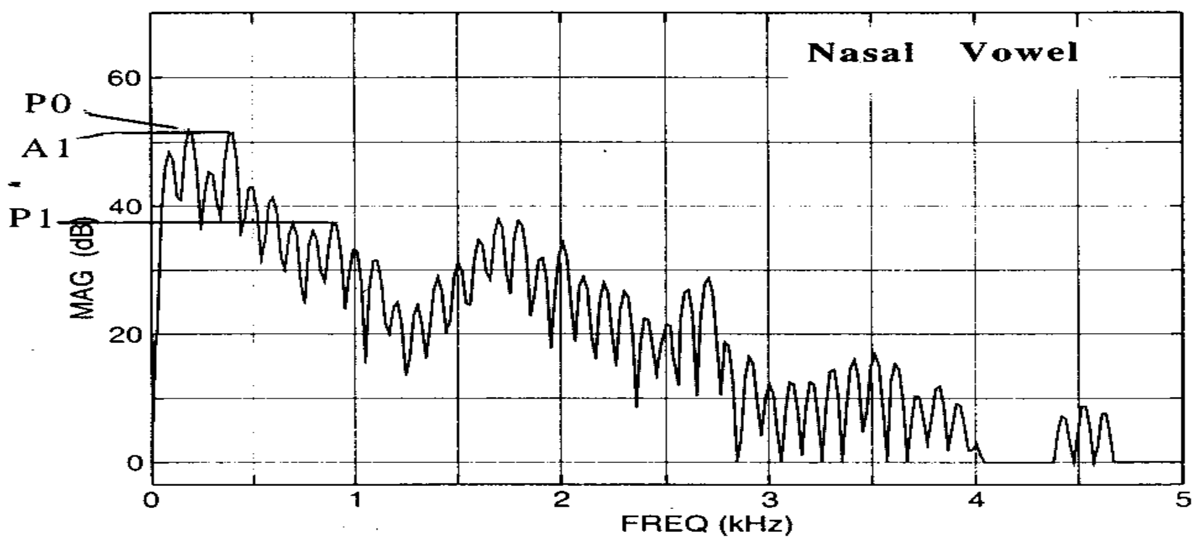
The results of her study confirmed that the amplitude of F1 in nasalized vowel reduces relative to its amplitude in oral vowel, and the extra nasality peaks were also noticed in spectrum. She compared the measures of A1-P1 and A1-P0 for Oral and nasal vowels. The results of her study demonstrated that the more the value of A1-P1 and A1-P0 is for vowel the lower that vowel is nasalized.

Chen (1997) took all these measures at three points: initial, middle and final within all the vowels. But she did not observe any differences among the measures taken at these three points in vowels. So she averaged these measures across three positions and got results. One picture of spectrum taken by Chen's work is portrayed on the next page. The measured acoustic parameters of nasalization (A1-P1 and A1-P0) in nasal and oral vowel are displayed. This figure is illustrating A1-P1 and A1-P0 measures taken at the middle of the oral and nasal vowel.

Figure.3.1. A1, P1, P0 Values Measured in Spectral Slice of Oral and Nasal Vowel in English



(a)



(b)

Source: From "*Acoustic correlates of English and French nasalized vowels"* by Chen, 1997, the Journal of the Acoustical Society of America

These two measures (A1-P1 and A1-P0) were used to study degree of nasalization in Punjabi and Pakistani English. In Punjabi the contextually nasal and contrastively nasal vowels were studied but in English only the contextually nasalized vowels were analyzed because English lacks oral/nasal contrast for vowels.

For high vowels the values of A1-P1 were measured and for A1-P0 were measured for low vowels. The reason for taking only P1 for /ɪ/ was the difficulty in measuring F_{P0} because of the low F1 of /ɪ/. F_{P0} is so close to F1 which makes F_{P0} undistinguished. On the other hand, the high F1 of /ʌ/, /æ/ and /ɒ/ makes the measure of F_{P1} unreliable (Chen, 1997). On the basis of vowels' height, Chen proposed A1-P0 for low vowels and A1-P1 for the high vowels as most reliable measures of nasalization. So, for the present study, the degree of nasalization was determined in Punjabi and English vowels using A1-P1 for high vowels and A1-P0 for low vowels.

After determining the degree of nasality in Punjabi and Pakistani English, the results were compared to see the similarities and differences between these two. These results were further compared with the values of vowel nasalization in American English, explored by Chen (1997). All the results of this study are presented in the form of tables and graphics.

Chapter Four

RESULTS

The frequency measures at which the values of A1, P1 and P0 were taken in both English and Punjabi nasalized vowels are given in table 1. There is no significant difference among frequency prominences at different locations within the same vowel on which the values of A1, P1 and P0 were taken. So the following table shows the values averaged across speakers, repetitions and locations (initial, medial, final).

Table.4.1. Frequencies of the nasal peaks and the first formant, averaged across speakers, repetitions and vowel positions, in English contextually nasalized vowels and Punjabi contextually and contrastively nasal vowels. F_{P1} and F_{P0} indicate the frequencies of nasal peaks on which the amplitudes P1 and P0 were measured, respectively.

	English nasalized			Punjabi nasalized		
Vowels	**F_{p0}(Hz)**	**F1(Hz)**	**F_{p1}(Hz)**	**F_{p0}(Hz)**	**F1(Hz)**	**F_{p1}(Hz)**
/ɪ/	-	409	976	-	423	1021
/ʌ/	285	604	-	304	754	-
/æ/	264	590	-	304	593	-
/ɒ/	270	584	-	-	-	-
/ɑ/	-	-	-	300	654	-
Average-	273			303		

In English nasalized vowels, except /ɪ/, the average F_{p0} ranged from 264 Hz to 285 Hz with an average of 273 Hz across vowels. While in Punjabi nasalized vowels, except /ɪ/, the average F_{p0} ranged from 300 Hz to 304 Hz with an average of 303 Hz across vowels. These values are not much different from the values measured by Chen. She stated the values of F_{p0} ranging from 206 Hz to 223 Hz, having the average of 216 Hz across vowels.

In English nasalized vowels, except /ʌ/, /æ/ and /ɒ/, the average F_{P1} was 976 Hz. While for Punjabi nasalized vowels, except/ʌ, /æ/ and /ɒ/, the F_{P1} was 1021 Hz. Chen (1997) described the F_{P1} in a range of 924 Hz to 1032 Hz, with 966 Hz average across vowels.

4.1. NASALIZATION IN PUNJABI VOWELS

4.1.1. Vowel /æ/

For Punjabi vowel / æ/, the speakers showed significant difference between the oral and nasal values. At initial portion of the vowel in “v + n” context, two speakers showed statistically significant difference between the $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values, which reflected the great degree of nasalization in the vowel in this context. The vowel was nasalized completely by the two speakers as it was depicting nasality effect even at its onset followed by an oral consonant.

In “v + n” context, all the four speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values at the medial point of the vowel / æ/, which reflected that all the speakers showed the nasality effect at middle portion of the vowel. While the values of A1-P0 taken at the final portion of oral and contextually nasalized vowels showed the great effect of neighboring nasal consonant on the offset of vowel. All the speakers showed statistically significant difference between the measures of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_{N.}$

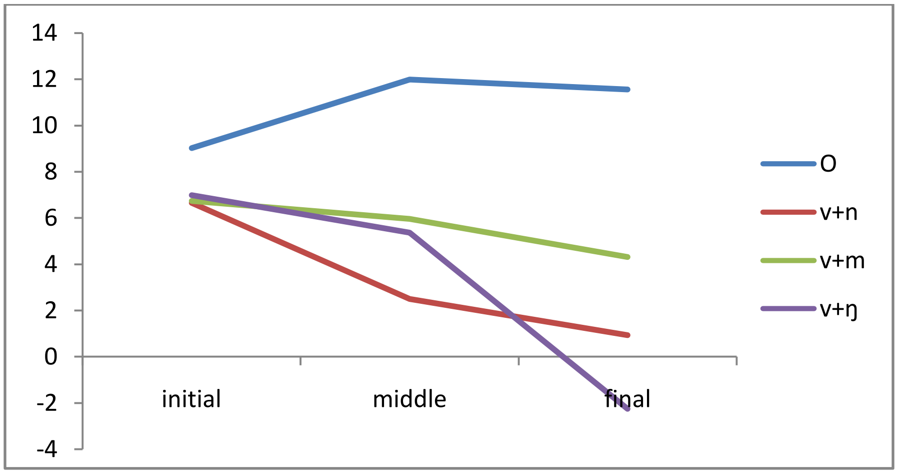
In "v + m" context, where the vowel was following the nasal consonant "m", A1-P0 showed nasality difference in the vowel in "v + m" context from the oral vowel. Three speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values at the initial portion of the vowel. Which suggested that the vowel in "v + m" context, was not showing the effect of its neighboring oral consonant even on its onset, due to the strong influence of the contextual nasalization.

At the middle portion of the vowel in "v + m" context, three speakers showed statistically significant difference between the measures of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_{N.}$ At the final point, all the four speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_{N.}$ So, the vowel clearly showed the nasality effect adopted from its neighboring nasal consonant.

For the vowel / æ / in "v + ŋ" vowel, there was the great impact of oral stop on the vowel at initial point. Only one of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ measures. In the other three speakers' production, the vowel in "v + ŋ" context was totally oral at its onset. At medial point, three speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_{N.}$ While at the finial point, all the four speakers showed statistically significant difference between the measures of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$. So, the vowel in "v + ŋ" context showed the strong nasalization on its offset. The given figure illustrates the trend of nasality in the vowel / æ / following the nasal consonants /n/, /m/ and / ŋ/.

The values for $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ measured to show contextual regressive nasalization in the vowel /æ/, are given in figure 1. For given speakers, the values of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ measured at initial, middle and end of the vowel / æ /, are stated in appendices A.

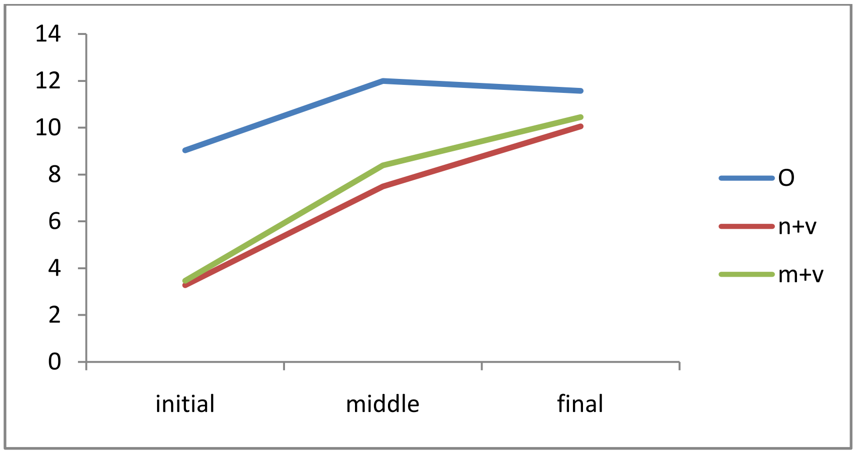
Figure.4.1. Average A1-P0 across Four Speakers and Repetitions, Measured within the Punjabi Vowel /æ/ in Oral and Nasal Contexts.



In the vowel /æ/ preceding the nasal consonant "n", all the four speakers showed statistically significant difference between the values of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_{N.}$ So the vowel showed strong effect of contextual nasalization at its onset. At the medial point of the vowel, three speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. At the final portion of the vowel, three speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. So, the vowel preceding nasal consonants /n/ and /m/, adopted nasality effect from its neighboring nasal consonant.

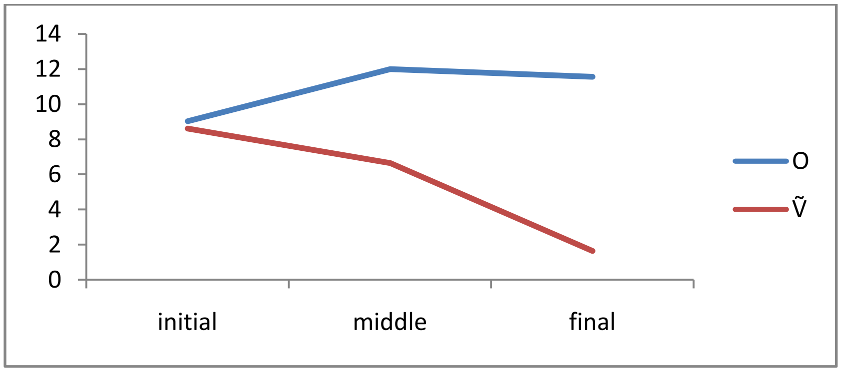
The values for $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ measured to show contextual progressive nasalization in the vowel /æ/, are given in figure 4.2.

Figure.4.2. Average A1-P0 across Four Speakers and Repetitions, measured within the Vowel /æ/ in Oral and Nasal Contexts.



The measures taken at the initial portion of the contrastively nasal vowel, showed no nasality feature at the onset of the vowel. None of the speakers showed statistically significant difference between the $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. While at the middle of the vowel, three speakers showed statistically significant difference between the values of A1-P0 measured at the oral vowel and the contrastively nasal vowel. At the final portion of vowel, all the speakers showed statistically significant difference between the $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values (see figure 3). That reflected the greater nasality on the offset of nasal vowel.

Figure.4.3. Average A1-P0 across Four Speakers and Repetitions, Measured within the Oral /æ/ and Contrastively Nasal /æ̃/ Vowel.



4.1.2. /ɪ/ Vowel

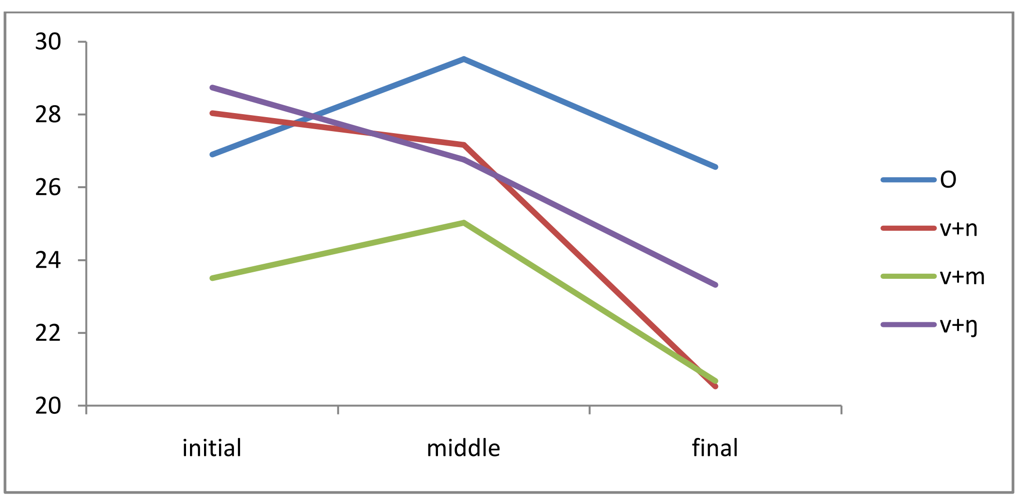
The vowel /ɪ/, showed clear difference between the A1-P1 values measured at the initial, medial and final portions of the vowel in different contexts. At the initial point of the vowel /ɪ/ in "v + n" context, none of the speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values, depicting a strong influence of neighboring oral consonant on its onset. At the middle of the vowel in "v + n" context, two speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values. While at the final portion of vowel, three speakers showed statistically significant difference between the values of $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$, reflecting the contextual nasalization on the offset of the vowel (see figure 7).

At the initial point of the vowel /ɪ/ in "v + m" context, two speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values. At the medial portion of vowel /ɪ/, two speakers showed statistically significant difference between the value of A1-P1 measured in the vowel in oral context and the vowel in nasal context. While at the final portion, all the four speakers showed statistically significant difference of (A1-P1) values between the vowels in oral and nasal contexts. So, the nasality effect was very significant at the offset of the vowel.

At the initial portion of vowel in "v + ŋ/ context, the vowel was free of nasality. None of the speakers showed statistically significant difference between the values of A1-P1 between the vowel in oral context and the vowel in nasal context. This depicted the influence of the neighboring oral consonant on the onset of vowel. While at the middle and also at the final portions of the vowel /ɪ/, two speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values, depicting the nasality effect on the vowel because of its neighboring nasal consonant.

The values for $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ measured to show contextual regressive nasalization in the vowel /ɪ/, are given in figure 4. For given speakers, the values of $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ measured at initial, middle and end of the vowel /ɪ/, are stated in appendix A.

Figure.4.4. Average A1-P1 across Four Speakers and Repetitions, Measured within the Vowel /ɪ/ in Oral and Nasal Contexts.

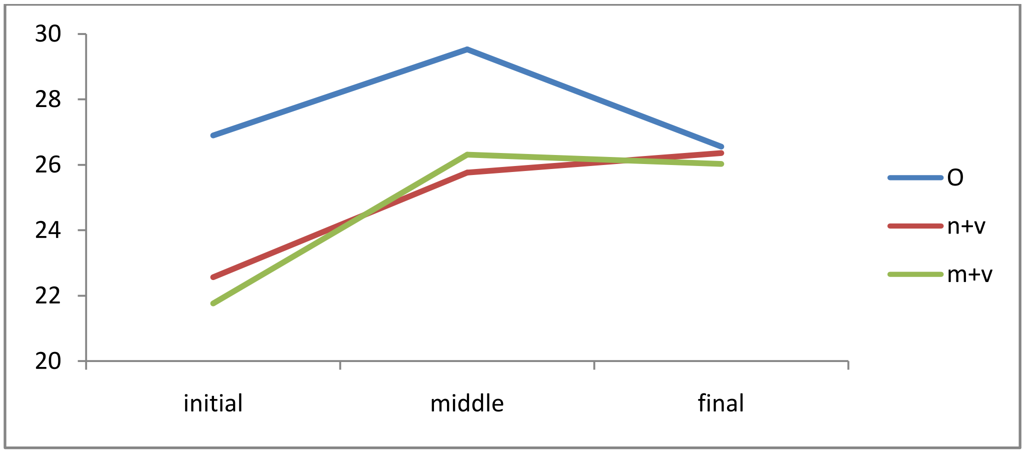


The values of $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ showed statistically significant difference at initial portion of the vowel /ɪ/ in “n + v” context, for three speakers. This depicted the nasality effect on the onset of the vowel preceding the nasal consonant. At the middle of vowel /ɪ/ in “n + v” context, Three speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ measures. While at the end of the vowel none of the speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ for /ɪ/. This reflected that there was no influence of nasality on the offset of the vowel.

For /ɪ/ in “m + v” context, there was a statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values measured at the initial portion of the vowel, for all the four speakers. This reflected the nasality influence at the onset of the vowel preceding “m”. At the medial point of the vowel, the measured values of $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ showed statistically significant difference for two speakers. At the end of the vowel, the vowel was free of nasality effect as no speaker showed statistically significant results for $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values.

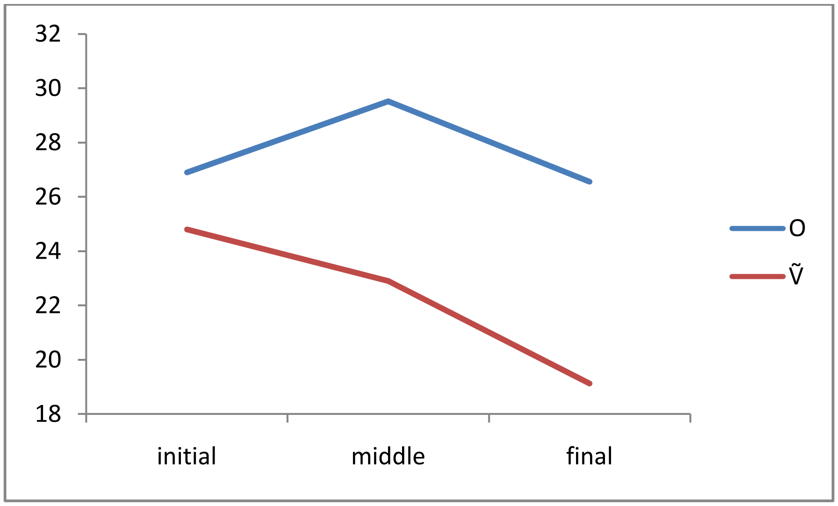
The values for $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ calculated to show contextual progressive nasalization in the vowel /ɪ/, are given in figure 4.5.

Figure.4.5. Average A1-P1 across Four Speakers and Repetitions, Measured within the Vowel /ɪ/ in Oral and Nasal Contexts.



For the vowel /ɪ/ in contrastively nasal context, only one speaker showed statistically significant difference between the $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ measures at initial portion of vowel. At the middle of the vowel, there was a statistically significant result between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$, for three speakers. At the final portion of the vowel, three speakers showed statistically significant difference between the values of $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$. Figure 6 illustrates the values for $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ measured to study contrastive nasalization in the vowel /ɪ/.

Figure.4.6. Average A1-P1 across Four Speakers and Repetitions, Measured within the Oral /ɪ/ and Contrastively Nasal /ɪ̃/ Vowel.



4.1.3. /ɑ/ Vowel

For the vowel /ɑ/ in “v + n” context, there was a statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values measured at the initial position in the vowel, for two speakers. At the middle of the vowel the measured values of $(A1\text{-}P1)_O$ and $(A1\text{-}P0)_N$ showed statistically significant difference for all speakers. In the final portion of vowel /ɑ/ in “v + n” context, all the four speakers showed statistically significant differences between $(A1\text{-}P1)_O$ and $(A1\text{-}P0)_N$ values, depicting the contextual effect of nasality on the offset of the vowel.

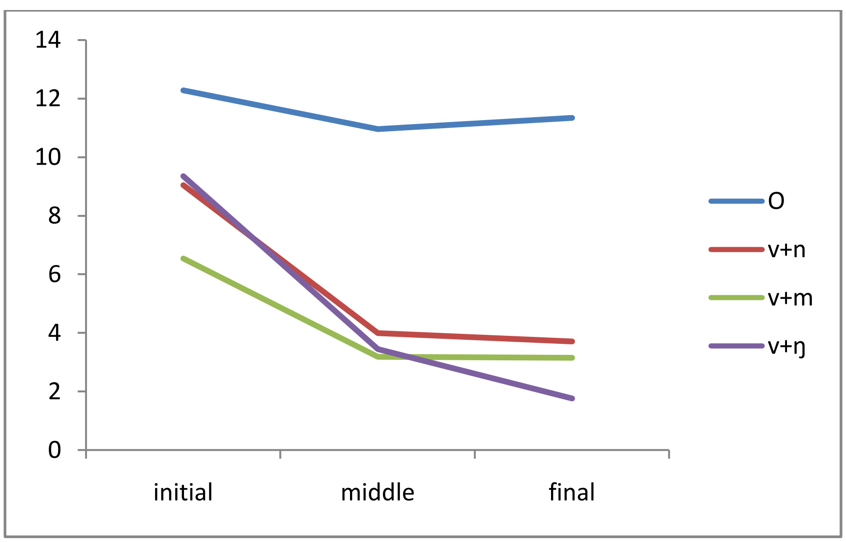
In the initial portion of the vowel /ɑ/ in “v + m” context, three speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P0)_N$ values. This nasality effect even on the onset of the vowel following a nasal consonant was an indicator of the vowel’s tendency to be nasalized completely. At the middle of the vowel /ɑ/ in “v + m” context, all the speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P0)_N$ measures.

Similarly all speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P0)_N$ values at the end of the vowel.

For the vowel /ɑ/ in “v + ŋ” context, two speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values taken at the initial portion of the vowel. At the middle of the vowel, there was a statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values for three speakers. While four speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values at the final portion of vowel in “v + ŋ” context.

The values for $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ taken in the /ɑ/ vowel to study contextual regressive nasalization, are stated in figure 7. The measures of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ at initial, middle and the end of the vowel /ɑ/ for four speakers are given in appendix A.

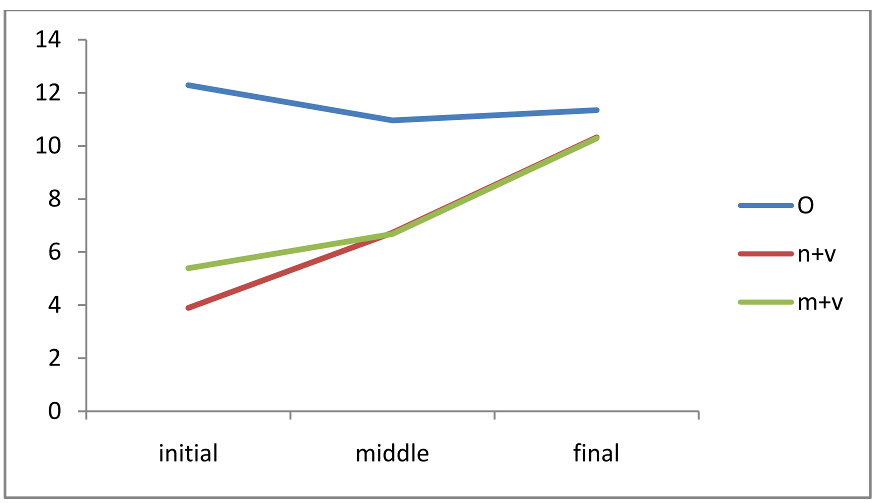
Figure.4.7. Average A1-P0 across Four Speakers and Repetitions, Measured within the Vowel /a/ in Oral and Nasal Contexts.



There was a statistically significant difference between the $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ measures at the initial point of the vowel /ɑ/ in “n + v” context, for all of the speakers. This mirrored the contextual nasalization on the onset of the vowel adapting nasality from its neighboring nasal consonant “n”. Two speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ measured in the middle of the vowel. While at the final portion of vowel in “n + v” context, $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ showed statistically significant difference for only one of the speakers.

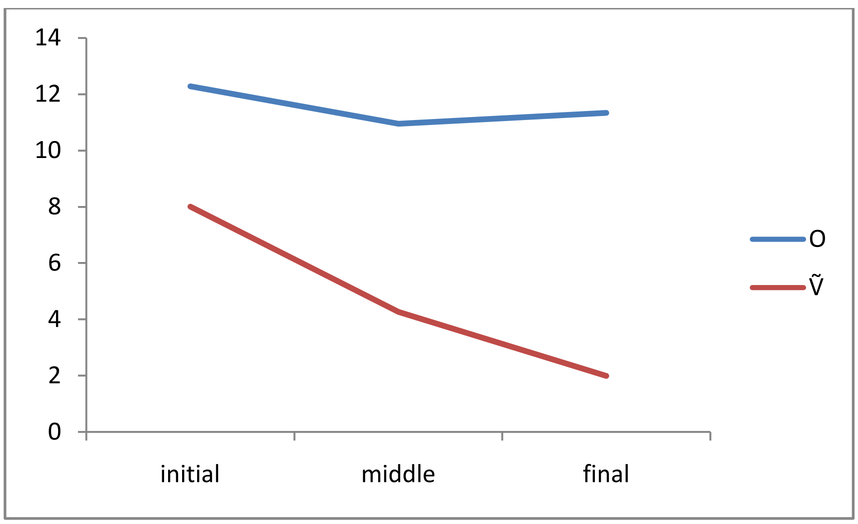
At initial point in the vowel /α/ in “m + v” context, there was a statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values for all of the speakers. This illustrated the nasality influence on the onset of the vowel where the vowel was preceding a nasal consonant. At the middle point of the vowel, there was a statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ for two speakers. While at the end of the vowel, none of the speakers showed statistically significant difference between the values measured in the vowel in nasal context and the vowel in oral context. So, the vowel was not depicting nasal influence on its offset (see figure 8).

Figure.4.8. Average A1-P0 across Four Speakers and Repetitions, Measured within the Vowel /a/ in Oral and Nasal Contexts.



For the contrastively nasal vowel /α̃/, three speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ at the beginning of the vowel. At the middle of the vowel, all the four speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P0)_N$. While at the end of the vowel, all the four speakers demonstrated statistically significant results. Figure 9 is depicting the values of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ taken to study the contrastive nasalization in /α/ vowel.

Figure.4.9. Average A1-P0 across Four Speakers and Repetitions, Measured within the Oral /a/ and Contrastively Nasal /ã/ Vowel.



4.1.4. /ʌ/ Vowel

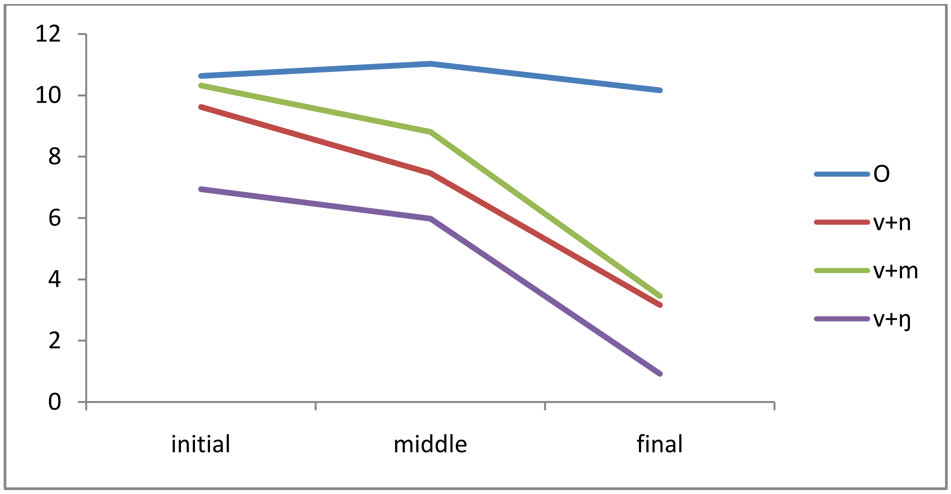
For the vowel /ʌ/ in "v + n" context, none of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values at the initial portion of the vowel. This reflected that the vowel is completely oral at its onset. At the middle of the vowel /ʌ/ in "v + n" context, three speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. While at the end of the vowel, all speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ measures. This showed that the vowel adopts nasality from its neighboring nasal consonant.

None of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values at the initial point of the vowel / ʌ/ in “v + m” context. So the onset of the vowel was free from nasality effect. At the middle of the vowel, two speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ measures. At the end of the vowel /ʌ/ in “v + m” context, all the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values, depicting the influence of nasality on the offset of the vowel following a nasal consonant.

For the vowel /ʌ/ in “v + ŋ” context, only one speaker showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values taken at the beginning of the vowel. At the middle of the vowel, all the four speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ measures. While at the end of the vowel, each of the four speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values, reflecting the effect of nasal consonant /ŋ / on the offset of vowel.

The values for $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ taken in the / ʌ / vowel to study contextual regressive nasalization, are mapped in figure 10. The measures of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ at initial, middle and the end of the vowel / ʌ / for different speakers are stated in appendices A.

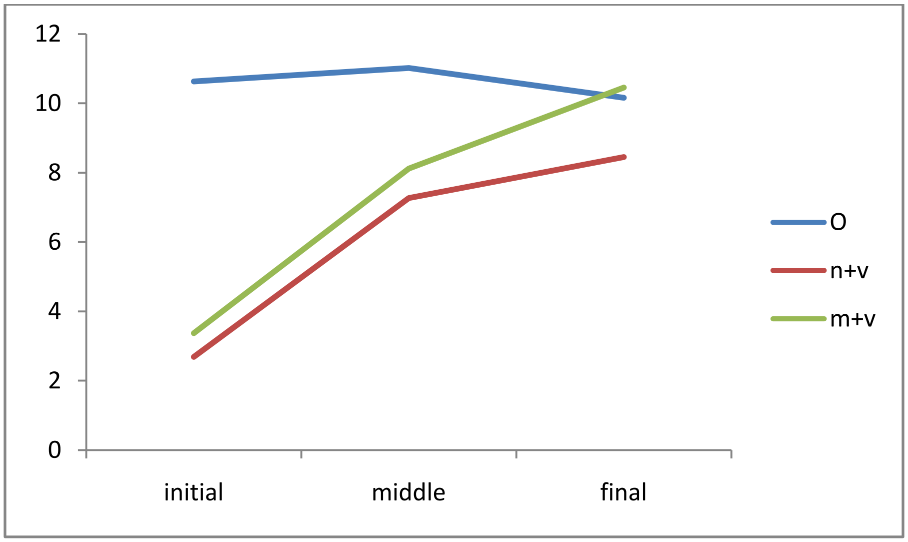
Figure.4.10. Average A1-P0 across Four Speakers and Repetitions, Measured within the Vowel /ʌ/ in Oral and Nasal Contexts.



For the vowel /ʌ/ in "n + v" context, all of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values measured at the initial portion of the vowel. This mirrored that the nasality effect is very prominent on the onset of the vowel preceding the nasal consonant /n/. At the middle of the vowel, three speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. While at the final portion of the vowel, two speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values.

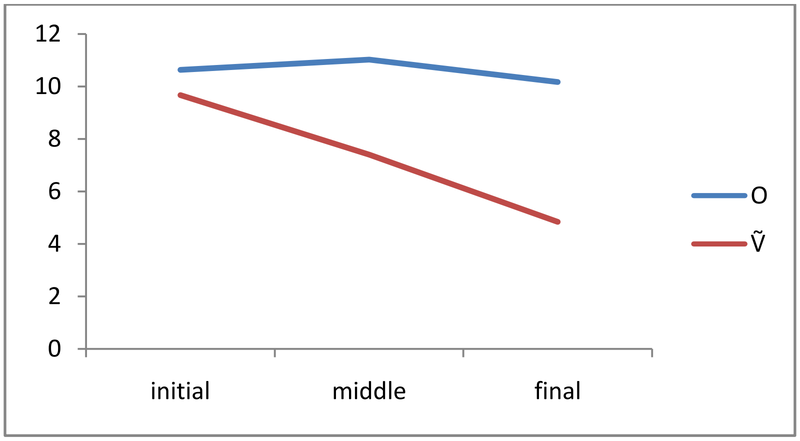
There was a statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values measured at the initial point of the vowel /ʌ/ in "v + m" context, for three speakers. While, at the middle of the vowel, two speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. At the end of the vowel, only one of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. The values for $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ of / ʌ / vowel to study contextual progressive nasalization are given in figure 11.

Figure.4.11. Average A1-P0 across Four Speakers and Repetitions, Measured within the Vowel /ʌ/ in Oral and Nasal Contexts.



None of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values taken at the beginning of the oral and contrastively nasal vowel, respectively. At the middle of the vowel, three of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. While, there was a statistically significant difference between the $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values measured at the final portion of the vowel /ʌ/ in contrastively nasal vowel, for all of the speakers. So the contrastively nasal vowel did not confirm nasality at its onset. The values of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ for / ʌ/ vowel to study contextual progressive nasalization are illustrated in figure 12.

Figure.4.12. Average A1-P0 across Four Speakers and Repetitions, Measured within the Oral /ʌ/ and Contrastively Nasal /ʌ̃/ Vowel.



To summarize the results, the Δ(A1-P0) value was also calculated for low vowels. Δ(A1-P0) was the measured difference between the average of $(A1\text{-}P0)_O$ and the average of $(A1\text{-}P0)_N$. The Δ(A1-P1) values was calculated for the high vowel, which was the difference between the average of $(A1\text{-}P1)_O$ and the average of $(A1\text{-}P1)_N$. The Δ(A1-P0) and Δ(A1-P1) were calculated for the three portions (initial, middle, final) of vowels in different contexts to see the degree of contrastive nasalization and contextual (regressive and progressive) nasalization.

For the vowels in "v + n" context, the mean, minima and maxima values for Δ(A1-P0) and Δ(A1-P1) at the initial portion of vowel, are given in table 4.2. The mean for Δ(A1-P0) ranged from 1 db to 3 db with the minima ranging from -4 db to 1 db and the maxima ranging from 3db to 6 db. While the mean for Δ(A1-P0) was -1 db with the minima of -5 and the maxima of 2 db measured for the high vowel /ɪ/.

Table.4.2. Δ(A1-P0)db and Δ(A1-P1)db Values at the Initial of the Vowels in "v + n" Context.

vowels	Δ(A1-P0)db			Δ(A1-P1)db		
	Mean	**min**	**max**	**mean**	**min**	**Max**
/ɪ/				-1	-5	2
/æ/	2	-4	6			
/a/	3	1	5			
/ʌ/	1	0	3			

At the middle of the vowels in "v + n" context, the mean for Δ(A1-P0) ranged from 4 db to 9 db with the minima ranging from 1 db to 6 and the maxima ranging from 6 db to 15 db. While the mean for Δ(A1-P1) was 2 db with the minima of -3 db and the maxima of 5db (see table 4.3).

Table.4.3. Δ(A1-P0)db and Δ(A1-P1)db Values at the Middle of the Vowels in "v + n" Context.

Vowels	Δ(A1-P0)db			Δ(A1-P1)db		
	mean	**Min**	**max**	**mean**	**min**	**max**
/ɪ/				2	-3	5
/æ/	9	6	15			
/a/	7	4	10			
/ʌ/	4	1	6			

At the final portion of the vowels in “v + n” context, the mean values for Δ(A1-P0) ranged from 7 db to 9 db with the minima ranging from 5 db to 6db and the maxima ranging from 10 db to 12 db. For the high vowel, the mean for Δ(A1-P0) was 6 db with the minima of 3 db and the maxima of 10 db. The mean, minima and maxima values for Δ(A1-P0) and Δ(A1-P1) are given in table 4.4.

Table.4.4. Δ(A1-P0)db and Δ(A1-P1)db Values at the End of the Vowels in “v + n” Context.

vowels	Δ(A1-P0)db			Δ(A1-P1)db		
	mean	**Min**	**max**	**Mean**	**min**	**max**
/ɪ/				6	3	10
/æ/	9	6	12			
/a/	8	5	10			
/ʌ/	7	5	10			

At the initial portion of the vowels in “v + m” context, the mean for Δ(A1-P0) ranged from 0 db to 6 db with the minima ranging from -2 db to 3 db and the maxima ranging from 4 db to 8 db. While for Δ(A1-P1), the mean was 3 db with the minima of 1 db and the maxima of 7 db. The values for Δ(A1-P0)db and Δ(A1-P1) are given in table 4.5.

Table.4.5. Δ(A1-P0)db and Δ(A1-P1)db Values at the Beginning of the Vowels in "v + m" Context.

vowels	Δ(A1-P0)db			Δ(A1-P1)db		
	mean	min	max	Mean	min	max
/ɪ/				3	1	7
/æ/	2	-2	5			
/a/	6	3	8			
/ʌ/	0	-1	4			

The values for Δ(A1-P0) and Δ(A1-P1) calculated at the middle of the vowels in "v + m" context, are given in table 4.6. The mean for Δ(A1-P0) ranged from 2 db to 8 db with the minima ranging from -3 db to 4 db and the maxima ranging from 6 db to 11 db. While the mean for Δ(A1-P1) was 4 db with the minima of 0 db and the maxima of 8 db.

Table.4.6. Δ(A1-P0)db and Δ(A1-P1)db Values at the Middle of the Vowels in "v + m" Context.

vowels	Δ(A1-P0)db			Δ(A1-P1)db		
	mean	Min	max	mean	min	max
/ɪ/				4	0	8
/æ/	6	4	8			
/a/	8	4	11			
/ʌ/	2	-3	6			

At the end of the vowels in “v + m” context, the mean for Δ(A1-P0) ranged from 7 db to 8 db with the minima ranging from 3 db to 5 db and the maxima ranging from 8 db to 11 db. For Δ(A1-P1), the mean was 6 db with the minima of 4 db and maxima of 8 db. (See table 4.7)

Table.4.7. Δ(A1-P0)db and Δ(A1-P1)db Values at the End of the Vowels in “v + m” Context.

vowels	Δ(A1-P0)db			Δ(A1-P1)db		
	mean	**min**	**max**	**mean**	**min**	**max**
/ɪ/				6	4	8
/æ/	7	3	11			
/a/	8	4	11			
/ʌ/	7	5	8			

The values of Δ(A1-P0)db and Δ(A1-P1) at the initial portion of the vowels in “v + ŋ” context, are give in table 4.8. For Δ(A1-P0), the mean was in the range of 2 db to 4 db with the minima ranging from -1 db to 2 db and the maxima ranging from 3 db to 6 db. While for (A1-P1), the mean was -2 db with -6 db minima and 2 db maxima.

Table.4.8. Δ(A1-P0)db and Δ(A1-P1)db Values at the Beginning of the Vowels in "v + ŋ" Context.

vowels	Δ(A1-P0)db			Δ(A1-P1)db		
	Mean	**min**	**max**	**mean**	**min**	**Max**
/ɪ/				-2	-6	2
/æ/	2	-1	3			
/a/	3	2	4			
/ʌ/	4	0	6			

At the middle of the vowels in "v + ŋ" context, the mean for Δ(A1-P0) ranged from 5 db to 8 db with the minima ranging from 2 db to 4 db and the maxima ranging from 6 db to 12 db. For Δ(A1-P1), the mean was 3 db with the minima of -1 db and the maxima of 4 db. The values for Δ(A1-P0)db and Δ(A1-P1) are given in table 4.9.

Table.4.9. Δ(A1-P0)db and Δ(A1-P1)db Values at the Middle of the Vowels in "v + ŋ" Context.

vowels	Δ(A1-P0)db			Δ(A1-P1)db		
	mean	**min**	**Max**	**mean**	**min**	**Max**
/ɪ/				3	-1	4
/æ/	7	2	12			
/a/	8	4	12			
/ʌ/	5	4	6			

The mean for Δ(A1-P1) at the end of the vowels in "v + ŋ" context, was in the range of 5 db to 6 db with the minima ranging from 2 db to 6 db and the maxima ranging from 8 db to 10 db. While the mean for Δ(A1-P1) was 3 db with the minima of 2 db and the maxima of 5 db. Table 4.10 illustrates the values for Δ(A1-P0)db and Δ(A1-P1) calculated at the end of vowels in "v + ŋ" context.

Table.4.10. Δ(A1-P0)db and Δ(A1-P1)db Values at the End of the Vowels in "v + ŋ" Context.

vowels	Δ(A1-P0)db			Δ(A1-P1)db		
	mean	**min**	**max**	**mean**	**min**	**max**
/ɪ/				3	2	5
/æ/	6	2	10			
/a/	8	6	10			
/ʌ/	5	4	8			

For the vowels in "n + v" context, the mean, minima and maxima values of Δ(A1-P0)db and Δ(A1-P1) calculated at the initial portion of vowels, are given in Table 4.11. The mean for Δ(A1-P0) ranged from 6 db to 8 db with the minima ranging from 3 db to 7 db and the maxima ranging from 7 db to 12 db. While the mean for Δ(A1-P1) was 4 db with 1 db minima and 7 db maxima.

Table.4.11. Δ(A1-P0)db and Δ(A1-P1)db Values at the Beginning of the Vowels in "n + v" Context.

vowels	Δ(A1-P0)db			Δ(A1-P1)db		
	mean	**min**	**max**	**mean**	**min**	**max**
/ɪ/				4	1	7
/æ/	6	3	7			
/a/	8	7	12			
/ʌ/	8	4	12			

At the middle of the vowels in "n + v" context, the mean for Δ(A1-P0) ranged from 4 db to 5 db with the minima ranging from 0 db to 2 db and the maxima ranging from 5 db to 9 db. For Δ(A1-P1), the mean was 4 db with the minima of 3 db and the maxima of 5 db. The values for Δ(A1-P0)db and Δ(A1-P1) calculated at the middle of the vowels in "n + v" context, are given in table 4.12.

Table.4.12. Δ(A1-P0)db and Δ(A1-P1)db Values at the Middle of the Vowels in "n + v" Context.

vowels	Δ(A1-P0)db			Δ(A1-P1)db		
	Mean	**min**	**max**	**mean**	**min**	**max**
/ɪ/				4	3	5
/æ/	5	1	7			
/a/	4	0	9			
/ʌ/	4	2	5			

The mean for Δ(A1-P0) calculated at the final portion of the vowels in "n + v" context, ranged from 1 db to 2 db with the minima ranging from -1 db to 0 db and the maxima ranging from 3 db to 4 db. While for Δ(A1-P1), the mean was 0 db with -2 db minima and 3 db maxima (see table 4.13).

Table.4.13. Δ(A1-P0)db and Δ(A1-P1)db Values at the End of the Vowels in "n + v" Context.

	Δ(A1-P0)db			**Δ(A1-P1)db**		
vowels	**Mean**	**min**	**max**	**mean**	**min**	**Max**
/ɪ/				0	-2	3
/æ/	2	0	4			
/a/	1	-1	4			
/ʌ/	2	0	3			

For the vowels in "m + v" context, the values of Δ(A1-P0)db and Δ(A1-P1) calculated at the initial portion of vowels are given in table 4.14. The mean for Δ(A1-P0) was in range of 6 db to 7 db with the minima ranging from 3 db to 5 db and the maxima ranging from 2 db to 14 db. For Δ(A1-P1), the mean was 5 db with the minima of 1 db and the maxima of 9 db.

Table.4.14. Δ(A1-P0)db and Δ(A1-P1)db Values at the Beginning of the Vowels in "m + v" Context.

vowels	Δ(A1-P0)db			Δ(A1-P1)db		
	mean	**min**	**Max**	**mean**	**min**	**Max**
/ɪ/				5	1	9
/æ/	6	5	7			
/a/	7	4	12			
/ʌ/	7	3	14			

At the middle of the vowels in "m + v" context, the mean for Δ(A1-P0) ranged from 3 db to 4 db with the minima ranging from 0 db to 1 db and the maxima ranging from 6 db to 8 db. While the mean for Δ(A1-P1) was 3 db with minima of 2 db and the maxima of 4 db. The values for Δ(A1-P0) and Δ(A1-P1) at the middle of the vowels in "m + v" context are given in table 4.15.

Table.4.15. Δ(A1-P0)db and Δ(A1-P1)db Values at the Middle of the Vowels in "m + v" Context.

vowels	Δ(A1-P0)db			Δ(A1-P1)db		
	Mean	**Min**	**max**	**mean**	**min**	**max**
/ɪ/				3	2	4
/æ/	4	0	6			
/a/	4	1	7			

/ʌ/	3	1	8			

For the vowels in "m + v" context, the mean for Δ(A1-P0) calculated at the end of the vowel, ranged from 1 db to 1 db with the minima ranging from -1 db to -1 db and the maxima ranging from 3 db to 5 db. Table 4.15 illustrates the mean, minima and maxima values for Δ(A1-P0) and Δ(A1-P1) calculated at the final portion of the vowels in "m + v" context.

Table.4.16. Δ(A1-P0)db and Δ(A1-P1)db Values at the End of the Vowels in "m + v" Context.

	Δ(A1-P0)db			**Δ(A1-P1)db**		
vowels	**mean**	**min**	**max**	**mean**	**min**	**max**
/ɪ/				1	-2	2
/æ/	1	-1	3			
/a/	1	-1	5			
/ʌ/	1	-1	3			

The mean for Δ(A1-P0) calculated at the initial portion of the contrastively nasal vowels, ranged from 0 db to 4 db with the minima ranging from -1 db to 4 db and the maxima ranging from 2 db to 2 db. While the mean for Δ(A1-P1) was 2 db with the minima of 0 db and the maxima of 5 db (see table 4.17).

Table.4.17. Δ(A1-P0)db and Δ(A1-P1)db Values at the Beginning of the Contrastively Nasal Vowels.

	Δ(A1-P0)db			**Δ(A1-P1)db**		
vowels	**mean**	**min**	**Max**	**mean**	**min**	**max**
/ɪ/				2	0	5
/æ/	0	-1	2			
/a/	4	4	7			
/ʌ/	1	0	2			

At the middle of the contrastively nasal vowels, the mean for Δ(A1-P0) ranged from 4 db to 7 db with the minima ranging from 1 db to 3 db and the maxima ranging from 6 db to 10 db. While for Δ(A1-P1), the mean was 7 db with the minima of 2 db and the maxima of 9 db. The values for Δ(A1-P0)db and Δ(A1-P1) calculated at the middle of the contrastively nasal vowels are given in table 4.18.

Table.4.18. Δ(A1-P0)db and Δ(A1-P1)db Values at the Middle of the Contrastively Nasal Vowels.

Δ(A1-P0)db				Δ(A1-P1)db		
vowels	**Mean**	**min**	**max**	**mean**	**min**	**max**
/ɪ/				7	2	9
/æ/	5	3	8			
/a/	7	2	10			
/ʌ/	4	1	6			

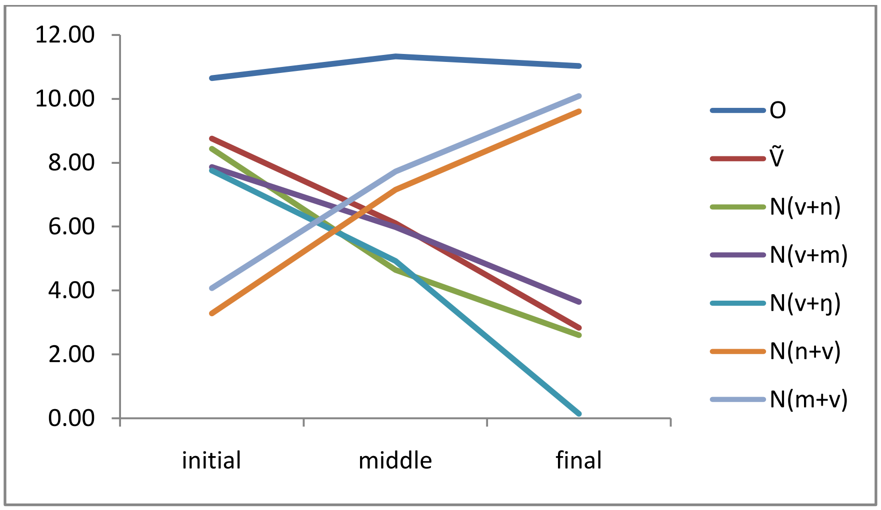
The values for Δ(A1-P0) and Δ(A1-P1) calculated at the final portion of the contrastively nasal vowels, are given in table 4.19. For Δ(A1-P0), the mean ranged from 5 db to 9 db with the minima ranging from 4 db to 7 db and the maxima ranging from 8 db to 12 db. While the mean for Δ(A1-P1) was 7 db with the minima of 5 db and the maxima of 11 db.

Table.4.19. Δ(A1-P0)db and Δ(A1-P1)db Values at the End of the Contrastively Nasal Vowels.

	Δ(A1-P0)db			Δ(A1-P1)db		
vowels	**Mean**	**min**	**max**	**mean**	**min**	**Max**
/ɪ/				7	5	11
/æ/	9	7	11			
/a/	9	5	12			
/ʌ/	5	4	8			

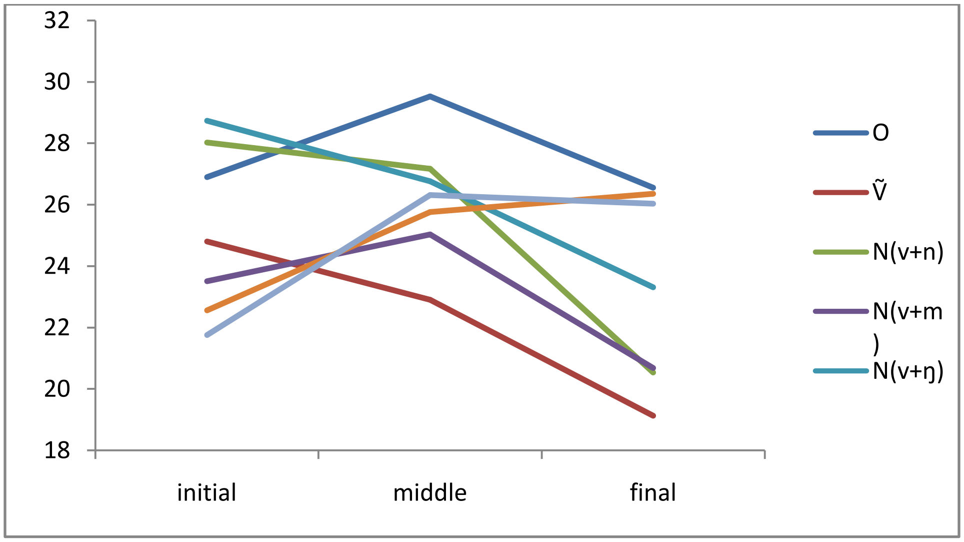
The average (A1-P0) across all the speakers and the vowels showed the direction of nasality very clearly (see figure 13). The vowels were consisting of much degree of nasalization at their onset when they are preceding the nasal consonant. This reflected the progressive nasality adapted by the context. On the other hand, the vowels following nasal consonants showed greater degree of nasality at their off sets. This reflected the regressive nasalization. While the contrastively nasal vowel showed greater nasality at the offset.

Figure.4.13. Average (A1-P0) across Vowels /æ,a,ʌ/ and Speakers (Four)



The average (A1-P1) across speakers, for the vowel /ɪ/, showed the similar direction of nasality as stated for (A1-P0) measure: greater degree of nasalization on the offset of vowel following nasal consonant, greater degree of nasalization on the onset of vowel preceding nasal consonant, greater degree of nasalization at the offset of contrastively nasal vowel (see figure 4.14).

Figure.4.14. Average (A1-P1) across Four Speakers for the Vowel /ɪ/



4.2. NASALIZATION IN PAKISTANI ENGLISH VOWELS

4.2.1. /æ/ Vowel

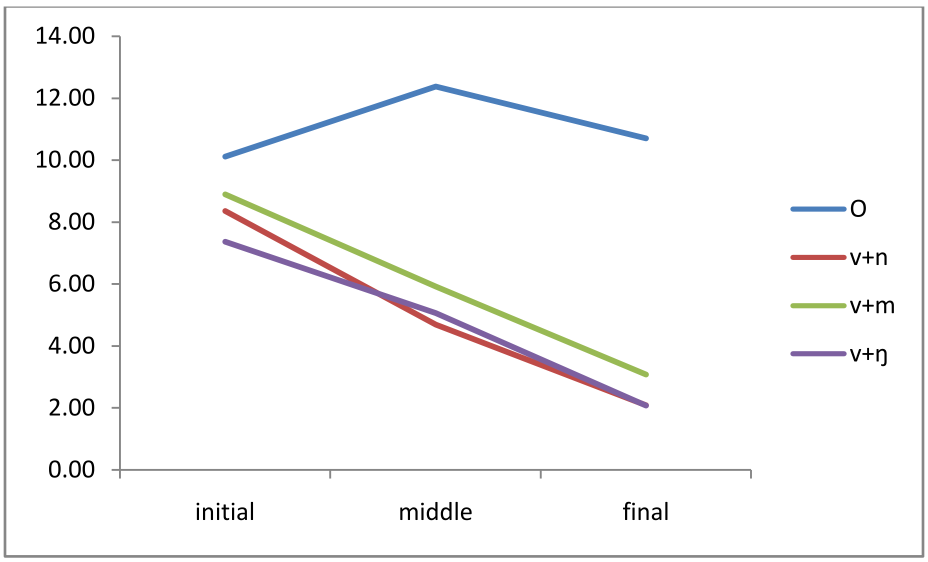
For the vowel /æ/ in "v + n" context, none of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values measured at the initial portion of the vowel. At the middle of the vowel, there was significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values for all of the speakers, depicting the nasality effect on the middle of the vowel. Similarly all the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values taken at the end of the vowel.

For the vowel /æ/ in "v + m" context, only one speaker showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values measured at the beginning of the vowel. So the vowel was not depicting a greater degree of nasality at its onset following /m/. At the middle of the vowel in "v + m" context, four of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ value. While at the end of the vowel, there was a statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ for all of the speakers, depicting nasality influence on the vowel.

At the initial portion of the vowel /æ/ in "v + ŋ", none of the speakers showed statistically significant difference between (A1-P0) value measured for the vowel in oral and nasal context. For the middle portion of the vowel in "v + ŋ" context, three of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. At the end of the vowel, four of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ measures.

The values for $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ averaged across speakers, measured at the three locations within the English vowel /æ/ to study regressive nasalization, are stated in figure 15. While the average $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values at the initial, middle and end of the vowel for given speakers are stated in appendix B.

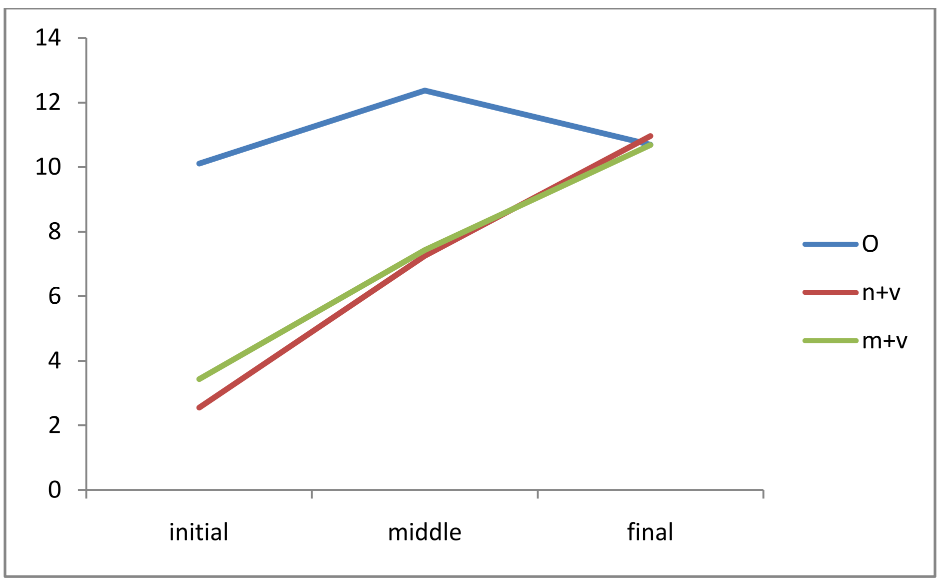
Figure.4.15. Average A1-P0 across Five Speakers and Repetitions, Measured within the Vowel /æ/ in Oral and Nasal Contexts.



For the vowel /æ/ in "n + v" context, there was a statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values measured at the initial portion of the vowel, for all of the speakers. So the vowel in "n + v" context showed the strong influence of nasality on its onset. At the middle of the vowel, four of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values, reflecting nasality effect in vowel. For the final portion of the vowel /æ/ in "n + v" context, only one speaker showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values, reflecting lack of nasality on the offset of the vowel.

For the vowel /æ/ in "m + v" context, all the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values calculated at the initial portion of the vowel. At the middle of the vowel, there was a statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ measures, for three of the speakers. While at the end of the vowel, none of the speakers showed statistically significant difference between the values of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$. Figure 16 is showing the pattern of progressive nasalization in the vowel /æ/.

Figure.4.16. Average A1-P0 across Five Speakers and Repetitions, Measured within the Vowel /æ/ in Oral and Nasal Contexts.



4.2.2. /ɪ/ Vowel

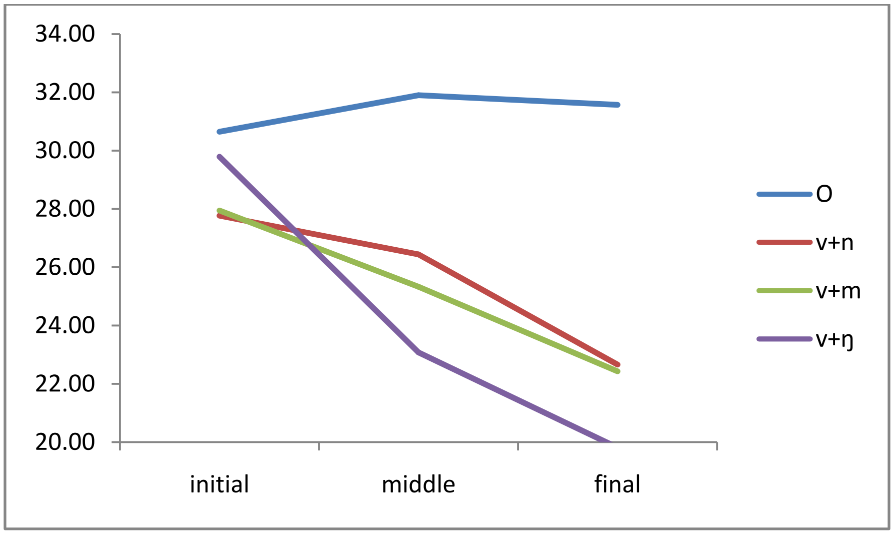
For the vowel /ɪ/ in "v + n" context, none of the speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values measured at the initial of the vowel. So the vowel was reflecting less influence of contextual nasality on its onset. At the middle of the vowel, three of the speakers showed statistically significant difference between the values of $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$. While at the end of the vowel in "v + n" context, four speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values. So the nasality affected the middle and the offset greater than its onset.

At the initial portion of the vowel /ɪ/ in "v + m" context, no one of the speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values. For the vowel /ɪ/ in "v + m" context, two speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values measured at the middle of the vowel. While at the end, four speakers showed statistically significant difference between the values of $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$.

For the vowel /ɪ/ in "v + ŋ" context, none of the speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values measured at the initial portion of the vowel. At the middle of the vowel in "v + ŋ" context, four of the speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values. At the end of the vowel, there was a significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values, for four of the speakers.

The $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values averaged across speakers, measured at the three locations (initial, middle and final) within the English vowel /ɪ/ to study regressive nasalization, are stated in figure 17. The average $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values at the initial, middle and end of the vowel for given speakers are stated in appendix B.

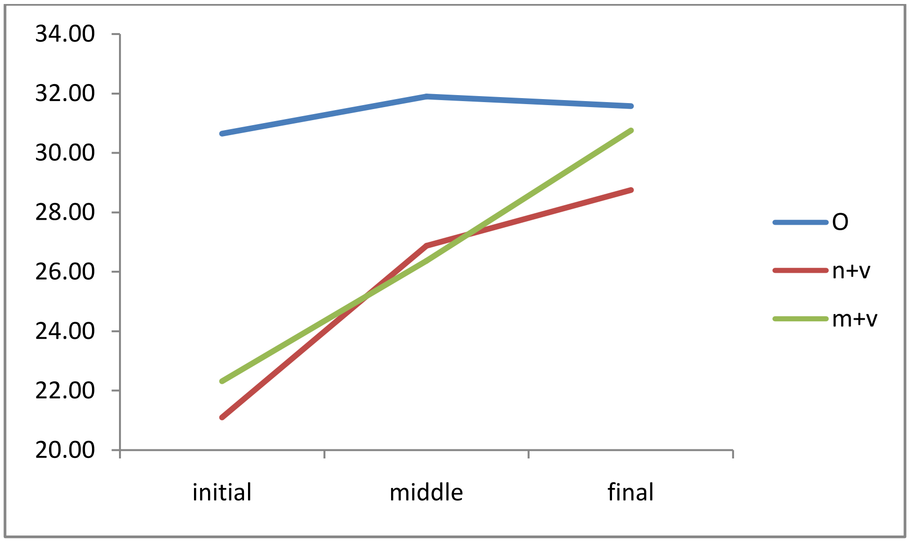
Figure.4.17. Average A1-P1 across Five Speakers and Repetitions, Measured within the Vowel /ɪ/ in Oral and Nasal Contexts.



For the vowel /ɪ in "n + v" context, all of the speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values calculated at the initial portion of the vowel. This reflected the high degree of nasalization on the onset of the vowel preceding /n/. At the middle of the vowel, three speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values. There was a statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values taken at the end of the vowel, only for one of the speakers.

The vowel /ɪ/ in "m + v" context, showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values measured at the beginning of the vowel, for four of the speakers, reflecting the higher degree of nasality at the vowel's onset. While at the middle of the vowel only one speaker and at the end of the vowel, none of the speakers showed statistically significant difference between $(A1\text{-}P1)_O$ and $(A1\text{-}P1)_N$ values. Figure 18 is illustrating the pattern of progressive nasalization in the vowel /ɪ/.

Figure.4.18. Average A1-P1 across Five Speakers and Repetitions, Measured within the Vowel /ɪ/ in Oral and Nasal Contexts.



4.2.3. /ɒ/ Vowel

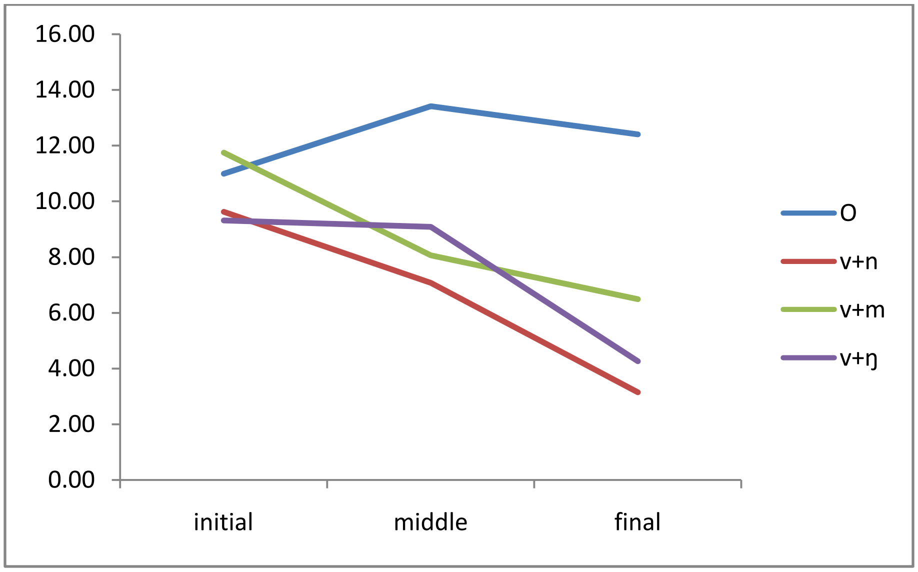
For the vowel /ɒ/ in "v + n" context, none of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values, measured at the initial portion of the vowel. At the middle of the vowel, four of the speakers showed statistically significant difference between the values of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$. At the end of the vowel in "v + n" context, there was a significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values, for all of the speakers, depicting the greater effect of nasal consonant on the offset of the vowel.

The vowel /ɒ/ in "v + m" context, did not show statistically significance difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values measured at the beginning of the vowel, for any speaker. At the middle of the vowel, there was a statistically significant difference between the values of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_{N,}$ for two of the speakers. While at the end of the vowel, three of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values, indicating the influence of contextual nasality on the vowel.

For the vowel /ɒ/ in "v + ŋ" context, none of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values, taken at the beginning of the vowel. At the middle of the vowel, three speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. While at the final portion of the vowel /ɒ/ in "v + ŋ" context, four of the speakers showed statistically significant difference between the values of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$.

The values for $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ averaged across speakers, measured at the three locations within the vowel / ɒ / to study regressive nasalization, are given in figure 19. While the average $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values at the initial, middle and end of the vowel for given speakers are stated in appendix B.

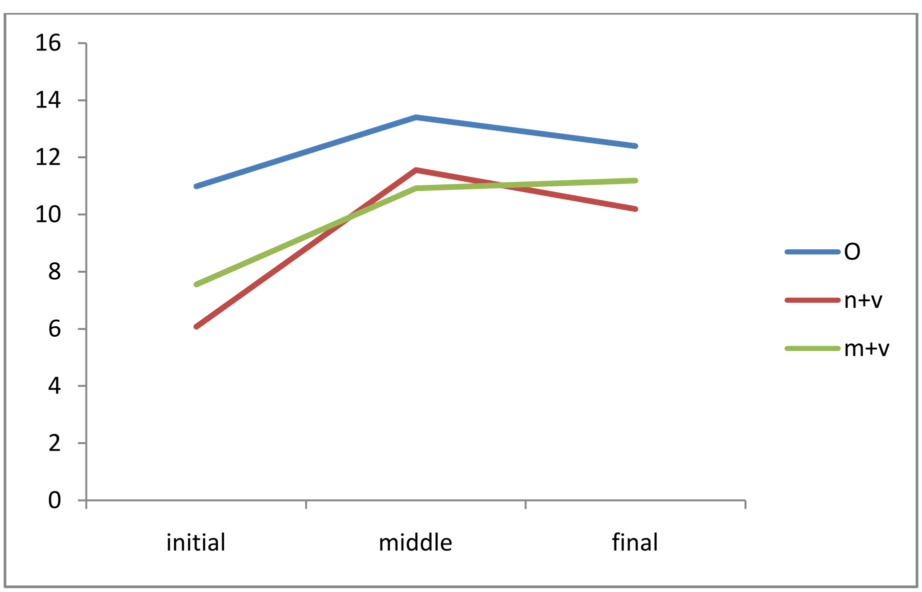
Figure.4.19. Average A1-P0 across Five Speakers and Repetitions, Measured within the Vowel /ɒ/ in Oral and Nasal Contexts.



For the vowel /ɒ/ in “n + v” context, four of the vowels showed statistically significant difference $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values measured at the initial portion of the vowel. This reflected the great degree of nasality at the onset of the vowel preceding nasal consonant /n/. At the middle of the vowel in “n + v” context, only one speaker showed statistically significant difference between the values of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_{N.}$ None of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values taken at the end of the vowel, reflecting that the nasality feature is not much dominant at the onset of the vowel.

At the initial portion of the vowel /ɒ/ in “m + v” context, four of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values (see figure 20). At the middle of the vowel, one of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. While for the final portion of the vowel in “m + v” context, none of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values.

Figure.4.20. Average A1-P0 across Five Speakers and Repetitions, Measured within the Vowel /ɒ/ in Oral and Nasal Contexts.



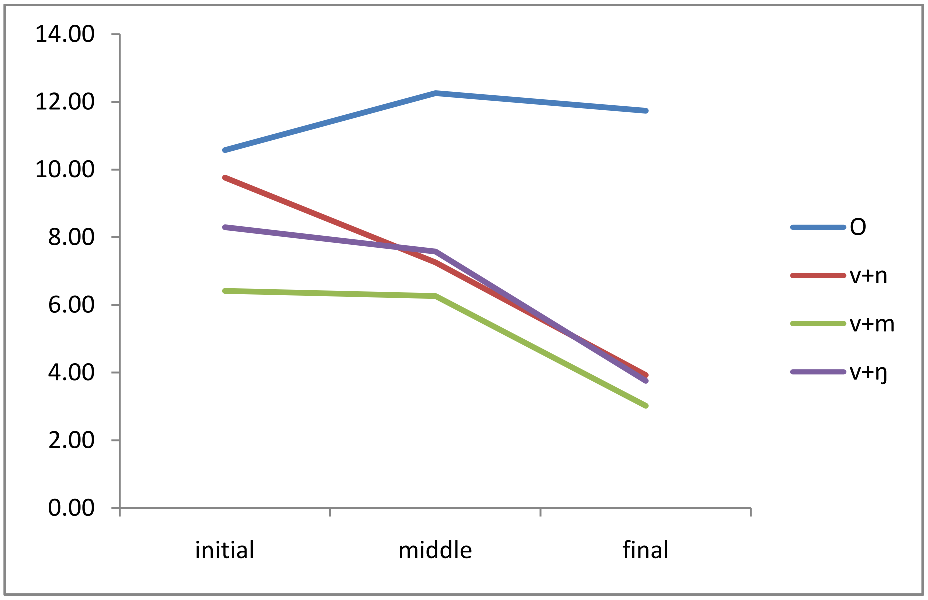
4.2.4. /ʌ/ Vowel

For the vowel /ʌ/ in "v + n" context, two of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values, taken at the initial portion of the vowel. At the middle of the vowel, three of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. While at the end of the vowel, four of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. This reflected the influence of nasality more on the offset and the middle of the vowel than its onset, following nasal consonant.

There was a statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values at the beginning of the vowel in "v + m" context, for two of the speakers. At the middle of the vowel, three speakers showed statistically significant difference between the values of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$. While for the final portion of the vowel, all of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. So the nasality effect was more prominent on the offset of the vowel.

For the vowel /ʌ/ in "v + ŋ" context, one of the speakers showed statistically significant difference between the values of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_{N,}$ take at the initial portion of the vowel. At the middle of the vowel, three speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. While for the end of the vowel, four speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values, reflecting the less influence of nasality at the onset of vowel and more influence on the middle and the end of the vowel (see figure 21). The values of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ measured at three locations initial, middle and beginning of vowel for given speakers are illustrated in appendix B.

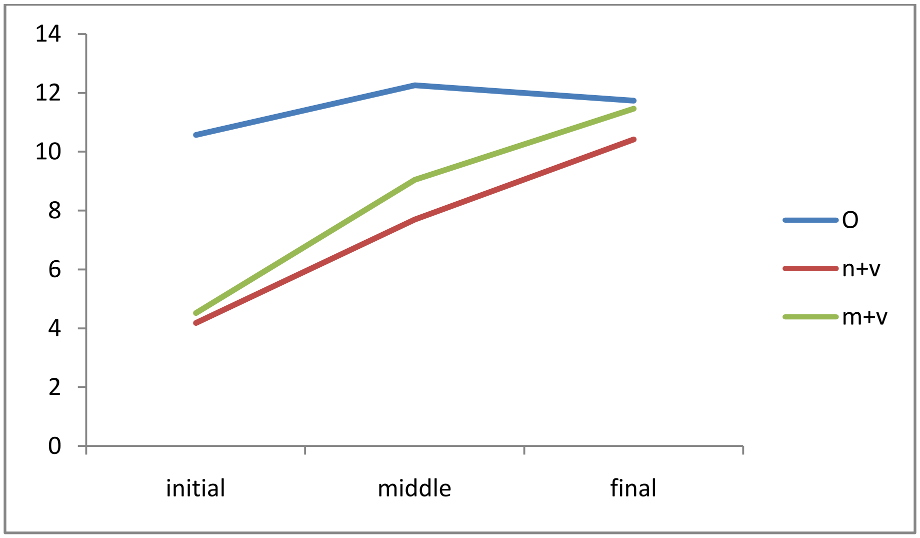
Figure.4.21. Average A1-P0 across Five Speakers and Repetitions, Measured within the Vowel /ʌ/ in Oral and Nasal Contexts.



For the vowel /ʌ/ in "n + v" context, all the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values, taken at the initial portion of the vowel. At the middle of the vowel, four speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. While at the end of the vowel, there was a statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values, for two of the speakers.

At the initial portion of the vowel /ʌ/ in "m + v" context, all speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. At the middle of the vowel, two speakers showed statistically significant difference between the values of $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$. While for the final portion of the vowel, none of the speakers showed statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values. This reflected the greater nasality influence on the onset of vowel preceding /m/. Figure 22 mirrors the pattern of progressive nasalization in /ʌ/ vowel.

Figure.4.22. Average A1-P0 across Five Speakers and Repetitions, Measured within the Vowel /ʌ/ in Oral and Nasal Contexts



For English vowels, the values of Δ(A1-P0) for the low and mid vowels and Δ(A1-P1) for the high vowel were calculated. Δ(A1-P0) was the difference between the average of $(A1\text{-}P0)_O$ and the average of $(A1\text{-}P0)_N$. while Δ(A1-P1) was the difference between the average of $(A1\text{-}P1)_O$ and the average of $(A1\text{-}P1)_N$.

For the initial portion of the vowels in "v + n" context, the mean for Δ(A1-P0) ranged from 1 db to 2 db with the minima ranging from -3 db to 0 db and the maxima ranging from 4 db to 6 db. The Δ(A1-P1) was 3 db with the minima of -2 db and the maxima of 9 db. The values for Δ(A1-P0) and Δ(A1-P1) calculated at the initial portion of vowels in "v + n" context, are given in table 4.20.

Table.4.20. Δ(A1-P0)db and Δ(A1-P1)db Values at the Beginning of the Vowels in "v + n" Context.

	Δ(A1-P0)db			Δ(A1-P1)db		
vowels	**mean**	**min**	**max**	**mean**	**min**	**Max**
/ɪ/				3	-2	9
/æ/	2	0	6			
/a/	1	-1	4			
/ʌ/	1	-3	6			

At the middle of the vowels in "v + n" context, the mean for Δ(A1-P0) ranged from 5 db to 8 db with the minima ranging from -2 db to 4 db and the maxima ranging from 12 db to 13 db. While for Δ(A1-P1), the mean was 5 db with the minima of 1 db and the maxima of 10 db. The mean, minima and maxima values for Δ(A1-P0) and Δ(A1-P1) calculated at the middle of the vowels in "v + n" context, are given in table 4.21.

Table.4.21. Δ(A1-P0)db and Δ(A1-P1)db Values at the Middle of the Vowels in "v + n" Context.

	Δ(A1-P0)db			Δ(A1-P1)db		
vowels	**mean**	**min**	**max**	**mean**	**min**	**max**
/ɪ/				5	1	10
/æ/	8	4	13			
/a/	6	2	12			

/ʌ/	5	-2	12			

For the vowels in "v + m" context, the mean for Δ(A1-P0) calculated at the end of the vowels, ranged from 5 db to 9 db with the minima ranging from 0 db to 5 db and the maxima ranging from 12 db to 16 db. While the mean for Δ(A1-P1) was 9 db with the minima of 4 db and the maxima of 15 db (see table 4.22).

Table.4.22. Δ(A1-P0)db and Δ(A1-P1)db Values at the End of the Vowels in "v + n" Context.

	Δ(A1-P0)db			**Δ(A1-P1)db**		
vowels	**mean**	**min**	**max**	**mean**	**min**	**max**
/ɪ/				9	4	15
/æ/	7	1	12			
/a/	9	5	16			
/ʌ/	5	0	15			

The mean for Δ(A1-P0) calculated at the initial portion of the vowels in "v + m" context, was in the range of -1 db to 4 db with the minima ranging from -3 db to 3 db and the maxima ranging from 0 db to 6 db. While the mean for Δ(A1-P1), was 3 db with -2 db minima and 13 db maxima. The values of Δ(A1-P0) and Δ(A1-P1) calculated at the beginning of the vowels in "v + m" context, are stated in table 4.23.

Tablee.4.23. Δ(A1-P0)db and Δ(A1-P1)db Values at the Beginning of the Vowels in "v + m" Context.

	Δ(A1-P0)db			Δ(A1-P1)db		
vowels	**Mean**	**min**	**max**	**mean**	**min**	**max**
/ɪ/				3	-2	13
/æ/	1	0	5			
/a/	-1	-3	0			
/ʌ/	4	3	6			

At the middle of the vowels in "v + m" context, the mean for Δ(A1-P0) ranged from 5 db to 6 db with the minima ranging from 2 db to 4 db and the maxima ranging from 10 db to 12 db. For Δ(A1-P1), the mean was 7 db with the minima of 2 db and the maxima of 12 db. The values for the vowels in "v + m" context calculated at the middle of the vowel, are given in table 4.24.

Table.4.24. Δ(A1-P0)db and Δ(A1-P1)db Values at the Middle of the Vowels in "v + m" Context.

	Δ(A1-P0)db			Δ(A1-P1)db		
vowels	**mean**	**Min**	**max**	**mean**	**min**	**max**
/ɪ/				7	2	12
/æ/	6	3	12			
/a/	5	2	10			
/ʌ/	6	4	11			

The values for Δ(A1-P0)db and Δ(A1-P1) calculated at the end of the vowels in "v + m" context, are given in table 4.25. For Δ(A1-P0), the mean ranged from 6 db to 8 db with the minima ranging from 2 db to 5 db and the maxima ranging from 11 db to 14 db. While the mean for Δ(A1-P1), was 9 db with the minima of 5 db and the maxima of 12 db.

Table.4.25. Δ(A1-P0)db and Δ(A1-P1)db Values at the End of the Vowels in "v + m" Context.

	Δ(A1-P0)db			Δ(A1-P1)db		
vowels	**Mean**	**min**	**max**	**mean**	**min**	**max**
/ɪ/				9	5	12
/æ/	8	5	11			
/a/	6	2	11			
/ʌ/	8	3	14			

For the vowels in "v + ŋ" context, the mean for Δ(A1-P0) calculated at the initial portion of the vowels ranged from 2 db to 3 db with the minima ranging from 0 db to 0 db and the maxima ranging from 3 db to 6 db. While the mean for Δ(A1-P1), was 1 db with the minima of -2 db and the maxima of 5 db. The values for Δ(A1-P0) and Δ(A1-P1) calculated at the beginning of the vowels in "v + ŋ" context, are stated in table 4.26.

Table.4.26. Δ(A1-P0)db and Δ(A1-P1)db Values at the Beginning of the Vowels in "v + ŋ" Context.

	Δ(A1-P0)db			Δ(A1-P1)db		
vowels	**Mean**	**min**	**max**	**mean**	**min**	**max**
/ɪ/				1	-2	5
/æ/	3	0	6			
/a/	2	0	3			
/ʌ/	2	0	4			

At the middle of the vowels in "v + ŋ" context, the mean for Δ(A1-P0) ranged from 4 db to 7 db. For Δ(A1-P0), the minima ranged from 0 db to 4 db and the maxima ranged from 8 db to 10 db. Whereas for Δ(A1-P1), the mean was 9 db with the minima of 3 db and the maxima of 16 db. The values for Δ(A1-P0) and Δ(A1-P1) considered in the middle of vowels in "v + ŋ" context, are given in table 4.27.

Table.4.27. Δ(A1-P0)db and Δ(A1-P1)db Values at the Middle of the Vowels in "v + ŋ" Context.

	Δ(A1-P0)db			Δ(A1-P1)db		
vowels	**mean**	**min**	**max**	**Mean**	**min**	**max**
/ɪ/				9	3	16
/æ/	7	4	10			
/a/	4	0	8			

/ʌ/	5	1	9			

For the vowels in "v + ŋ" context the mean for Δ(A1-P0) calculated at the final portion of the vowels ranged from 7 db to 9 db with the minima ranging from 4 db to 4 db and the maxima ranging from 10 db to 13 db. The mean for Δ(A1-P1) was 12 db with the minima of 6 db and the maxima of 18 db. The mean with minima and maxima values for Δ(A1-P0)db and Δ(A1-P1) calculated at the final portion of vowels in "v + ŋ" context, are stated in table 4.28.

Table.4.28. Δ(A1-P0)db and Δ(A1-P1)db Values at the End of the Vowels in "v + ŋ" Context.

	Δ(A1-P0)db			**Δ(A1-P1)db**		
vowels	**Mean**	**min**	**max**	**mean**	**min**	**Max**
/ɪ/				12	6	18
/æ/	9	4	12			
/a/	8	4	10			
/ʌ/	7	4	13			

For the vowels in "n + v" context, the mean calculated at the beginning of the vowels ranged from 5 db to 8 db with the minima ranging from 1 db to 4 db and the maxima ranging from 7 db to 14 db. While the mean for Δ(A1-P1) was 10 db with the minima of 5 db and the maxima of 15 db.(see table 4.29)

Table.4.29. Δ(A1-P0)db and Δ(A1-P1)db Values at the Beginning of the Vowels in "n + v" Context.

	Δ(A1-P0)db			Δ(A1-P1)db		
vowels	**Mean**	**min**	**max**	**mean**	**min**	**Max**
/ɪ/				10	5	15
/æ/	8	4	9			
/a/	5	1	7			
/ʌ/	6	1	14			

For the vowels in "n + v" context, the mean for Δ(A1-P0) calculated at the middle of the vowels, ranged from 2 db to 5 db with the minima of 0 db and the maxima ranging from 7 db to 10 db. while the mean for Δ(A1-P1) was 5 db with the minima of 3 db and the maxima of 7 db. The valued for Δ(A1-P0) and Δ(A1-P1) calculated at the middle of vowels in "n + v" context, are given in table 4.30.

Table.4.30. Δ(A1-P0)db and Δ(A1-P1)db Values at the Middle of the Vowels in "n + v" Context.

	Δ(A1-P0)db			Δ(A1-P1)db		
vowels	**mean**	**min**	**max**	**mean**	**min**	**max**
/ɪ/				5	3	7
/æ/	5	0	8			
/a/	2	0	7			

/ʌ/	5	0	10			

At the final portion of vowels in “n + v” context, the mean for Δ(A1-P0) ranged from 0 db to 2 db with the minima ranging from -2 db to 0 db and the maxima ranging from 4 db to 6 db. While the mean for Δ(A1-P1) was 3 db with the minima of 0 db and the maxima of 6 db. the values for Δ(A1-P0) and Δ(A1-P1) at the end of the vowels in “n + v” context, are illustrated in table 4.31.

Table.4.31. Δ(A1-P0)db and Δ(A1-P1)db Values at the End of the Vowels in “n + v” Context.

Δ(A1-P0)db				**Δ(A1-P1)db**		
vowels	**mean**	**min**	**max**	**mean**	**min**	**max**
/ɪ/				3	0	6
/æ/	0	-2	4			
/a/	2	0	5			
/ʌ/	1	-2	6			

For the vowels in “m + v” context, the mean for Δ(A1-P0) calculated at the initial portion of the vowels, ranged from 3 db to 7 db with the minima ranging from -1 db to 5 db and the maxima ranging from 5 db to 11 db. While the mean for Δ(A1-P1) was 8 db with the minima of 6 db and the maxima of 13 db. (see table 4.32)

Table.4.32. Δ(A1-P0)db and Δ(A1-P1)db Values at the Beginning of the Vowels in "m + v" Context.

	Δ(A1-P0)db			Δ(A1-P1)db		
vowels	**mean**	**min**	**max**	**mean**	**min**	**max**
/ɪ/				8	6	13
/æ/	7	5	11			
/a/	3	-1	5			
/ʌ/	6	1	11			

At the middle of the vowels in "m + v" context, the mean for Δ(A1-P0) ranged from 2 db to 5 db with the minima ranging from -2 db to 1 db and the maxima ranging from 5 db to 9 db. For Δ(A1-P1), the mean was 6 db with the minima of 3 db and the maxima of 10 db. The values for Δ(A1-P0)db and Δ(A1-P1) counted at the middle of the vowels in "m + v" context, are given in table 4.33.

Table.4.33. Δ(A1-P0)db and Δ(A1-P1)db Values at the Middle of the Vowels in "m + v" Context.

	Δ(A1-P0)db			Δ(A1-P1)db		
vowels	**mean**	**min**	**max**	**mean**	**min**	**max**
/ɪ/				6	3	10
/æ/	5	-2	8			
/a/	2	1	9			

/ʌ/	3	-1	5			

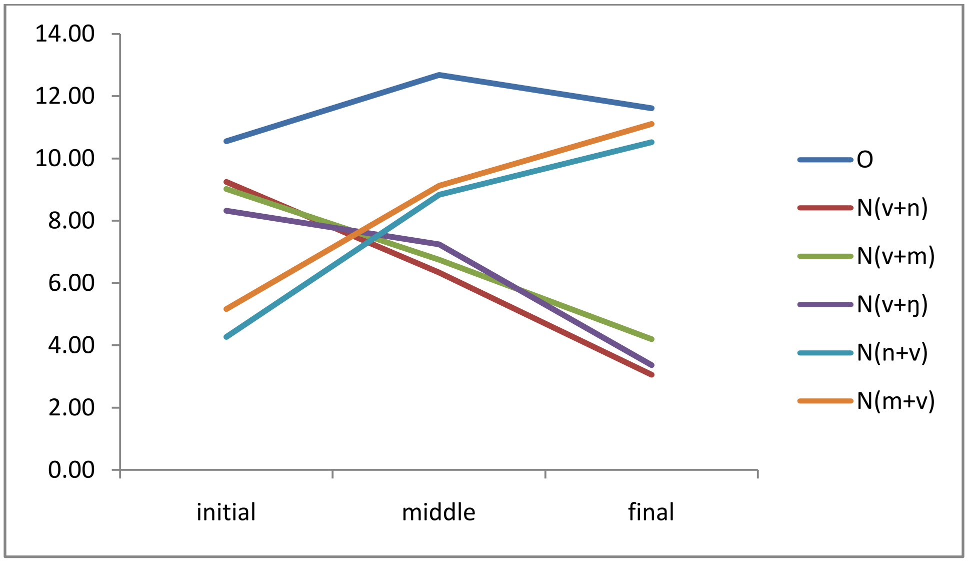
For the vowels in "m + v" context, the mean 0f Δ(A1-P0) calculated at the end of the vowels ranged from 0 db to 1 db with the minima of -1 db to -2 db and the maxima ranging from 2 db to 3 db. While the mean for Δ(A1-P1) was 1 db with -1 db minima and 3 db maxima.(see table 4.34)

Table.4.34. Δ(A1-P0)db and Δ(A1-P1)db Values at the End of the Vowels in "m + v" Context.

	Δ(A1-P0)db			**Δ(A1-P1)db**		
vowels	**mean**	**min**	**max**	**mean**	**min**	**max**
/ɪ/				1	-1	3
/æ/	0	-1	2			
/a/	1	0	3			
/ʌ/	0	-2	3			

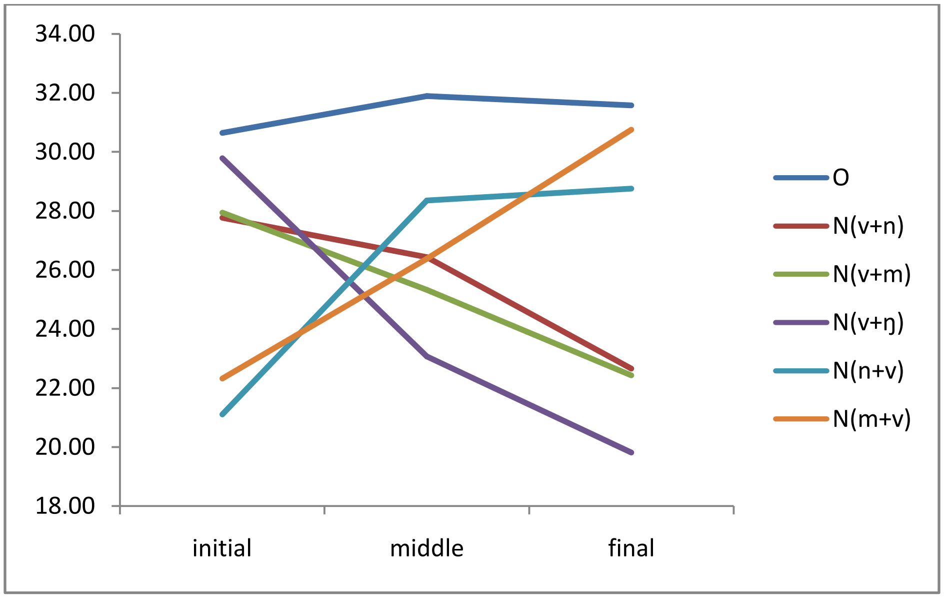
The average (A1-P0) across five speakers and the vowels illustrated the direction of nasalization very clearly in English produced by Punjabi speakers (see figure 23). The vowels showed greater degree of nasalization at their onset when they occur after the nasal consonant. This reflected the progressive nasality adapted by the context. On the other hand, the vowels showed greater degree of nasality at their off sets when they occur before nasal consonant. This reflected the regressive nasalization.

Figure.4.23. Average (A1-P0) across Vowels /a, ʌ, æ /and Speakers (Five)



The average (A1-P1) across five speakers for /ɪ/ vowel showed the similar direction of nasalization as the average of (A1-P0) illustrated (see figure 4.24). The vowels showed much degree of nasalization at their onset while preceding nasal consonant, reflecting the progressive nasality adapted by the context. On the other hand, the vowels showed greater degree of nasality at their off sets while following nasal consonant, depicting regressive nasalization.

Figure.4.24. Average (A1-P1) across Speakers (Five)



Chapter Five

DISCUSSION

5.1. ANTICIPATORY Vs CARRYOVER NASALIZATION

The results obtained from the data depicted a greater degree of anticipatory contextual nasalization in Punjabi language. The averaged Δ(A1-P0) across vowels/æ, α, ʌ/ and the Δ(A1-P1) for the vowel /ɪ/ across speakers and repetitions reflected the tendency of Punjabi speakers to nasalize vowels greatly in VN context than NV. For the vowels in VN context, the velum started to lower from the onset of the vowels to allow coupling between the oral and nasal cavities making the vowel to adopt +nasal feature. So the nasality gradually increased from onset to the offset of vowels following nasal consonants /n, m, ŋ/. The average Δ(A1-P0) across vowels /æ, a, ʌ/ , contexts (v+ n, v+ m, v+ ŋ), speakers and repetitions, was 3 db, 6 db and 7 db at onset, middle and offset of vowels, respectively. Similarly, the Δ(A1-P1) for /ɪ/ averaged across contexts (v+ n, v+ m, v+ ŋ), speakers and repetitions, was 0 db at onset, 3 db at middle and 5db at offset of the vowel.

Inversely, velum lowered from onset to the offset of vowels in NV context allowing greater coupling between oral and nasal cavities at the onset of the vowel. So the nasality gradually decreased from onset to the offset of the vowels preceding nasal consonants. The average Δ(A1-P0) across vowels /æ, α, ʌ/ , contexts (n+ v, m+ v), speakers and repetitions, was 7 db, 4 db and 1 db at initial, middle and final portions of vowels, respectively. In the same way, the average Δ(A1-P1) across contexts (n+ v, m+ v), speakers and repetitions for /ɪ/, was 5 db, 3 db and 0 db at the onset, middle and the offset of vowels in NV context.

At the middle of the vowels, the Δ(A1-P0) and Δ(A1-P1) values was greater for the vowels in VN context than the vowels in NV context. This reflected the higher degree of anticipatory nasalization in Punjabi vowels. The figure given below describes the degree of nasalization in both the anticipatory and carryover directions in Punjabi contextually nasalized vowels.

Figure.5.1. Average Δ(A1-P0) across Vowels (æ, ɑ, ʌ), Speakers and Repetitions, in Punjabi Vowels

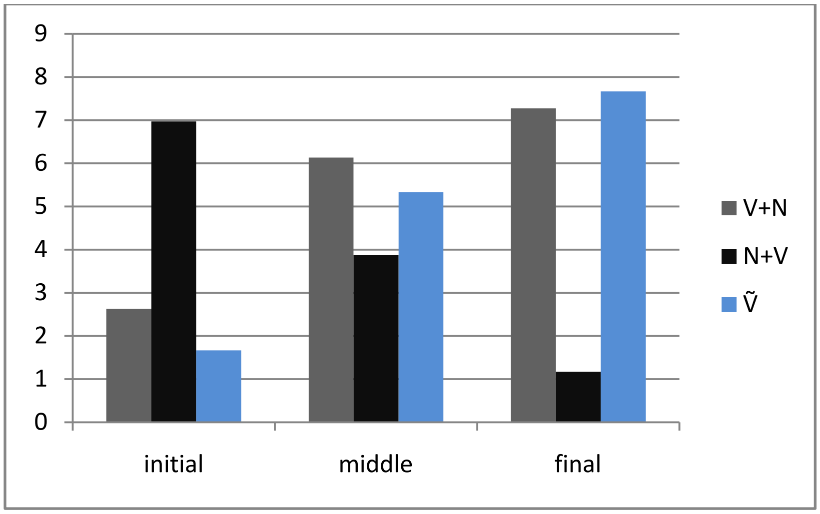
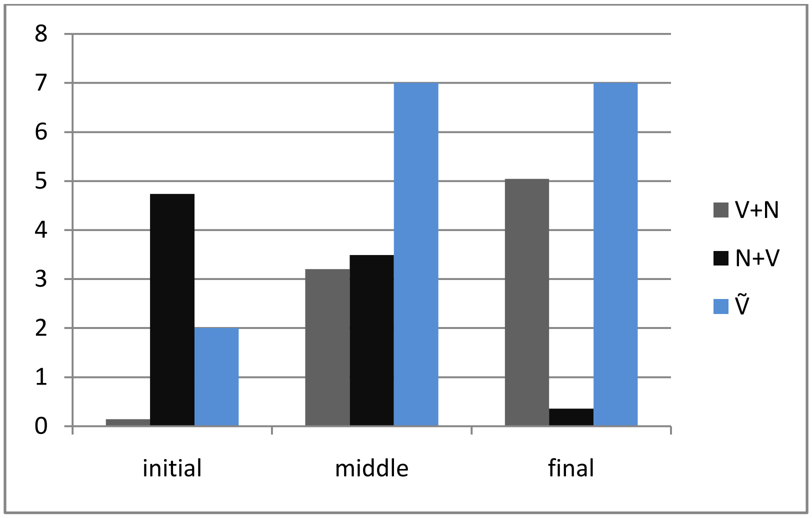


Figure.5.2.Average Δ(A1-P1) across Speakers and Repetitions for Punjabi Vowel /ɪ/



The contrastively nasal vowels /æ̃/, /ɑ̃/, /ʌ̃/ and /ĩ/ in Punjabi showed the tendency of containing higher degree of nasalization at the offset. Nasality increased gradually from onset to the offset of contrastively nasal vowels. The average Δ(A1-P0) across vowels /æ̃, ɑ̃, ʌ̃/, speakers and repetitions, was 2db, 5 db and 8 db at the onset, middle and offset of the vowels, respectively. Similarly, the average Δ(A1-P1) across speakers and repetitions for /ɪ/, was 2 db, 7 db and 7 db at the onset, middle and the offset of vowel. This reflected that the velum lowed gradually from onset to offset.

For Pakistani English vowels in VN context, the average Δ (A1-P0) across vowels /æ, ɒ, ʌ/, contexts (v+ n, v+ m, v+ ŋ), speakers and repetitions, was 2 db, 6 db and 7 db on the onset, middle and the offset of the vowels, respectively. Similarly, the average Δ (A1-P1) across speakers, repetitions and contexts (v+ n, v+ m, v+ ŋ) for /ɪ/, was 2 db at onset, 7 db at middle and 10 db at the offset of vowel. This reflected that the velum lowered gradually from onset to the offset of the vowels in VN context, allowing coupling between the nasal and oral cavities while the production of vowels. So the nasality increased gradually from onset to the offset in the vowels in VN context.

On the other hand, the vowels in NV context, showed tendency to be nasalized more at their onset than offset. The Δ (A1-P0) averaged across vowels /æ, ɒ, ʌ/, contexts (n+ v, m+ v), speakers and repetitions, was 5 db, 4 db and 1 db at the onset, middle and offset of the vowels, respectively. In the same way, the Δ (A1-P1) for /ɪ/ vowel averaged across speakers, repetitions and contexts (n+ v, m+ v), was 9 db at onset, 5 db at middle and 2 db at offset of the vowel. This showed that there was a great coupling between the oral and nasal cavities at the onset of the vowel in VN context. So, the nasality decreased gradually from onset to the offset of the vowel.

At the middle of the vowel, the degree of nasalization is greater for the vowels in VN context. So the English vowels preferred anticipatory nasalization. This confirmed the results of previous researches on English, that the English language preferred anticipatory nasalization than carryover (Chen, 2007). Figure 27 describes the nasalization pattern in English.

Figure.5.3.Average Δ(A1-P0) across Vowels /æ, ɒ, ʌ/, Speakers and Repetitions, in English Vowels

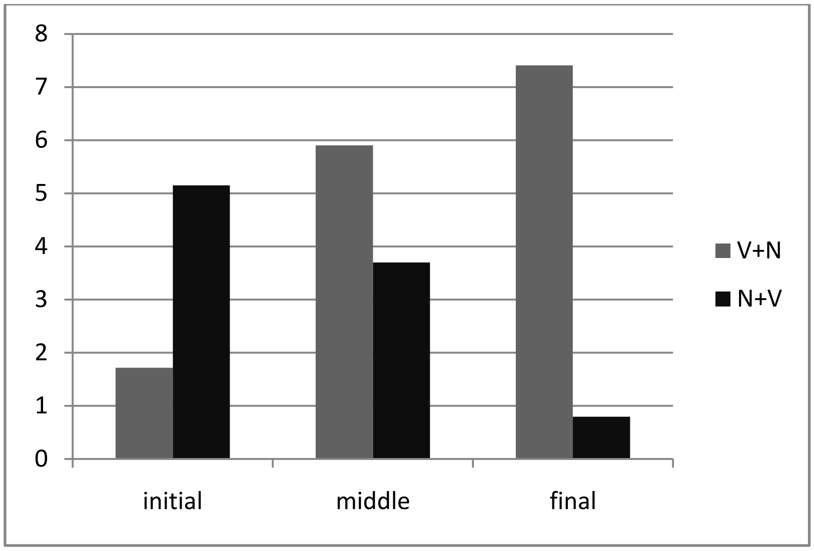
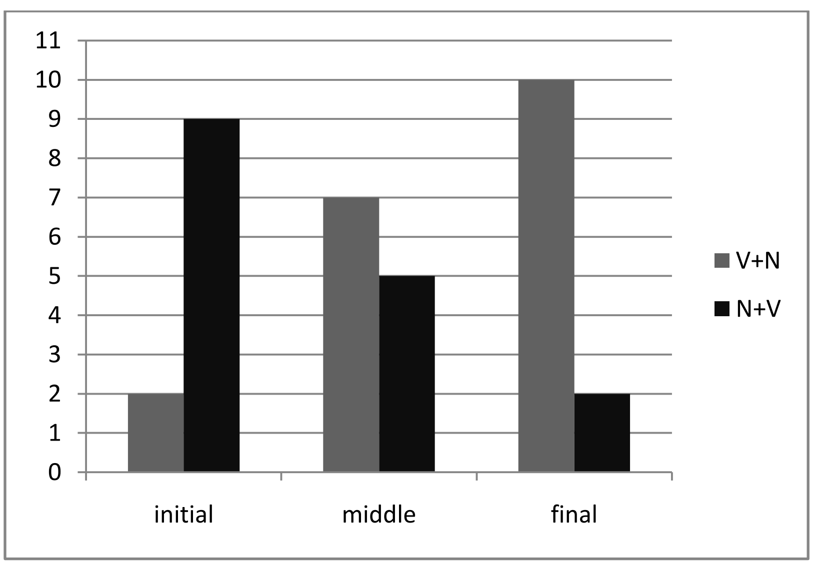


Figure.5.4. Average Δ(A1-P1) across Speakers and Repetitions for English Vowel /ɪ/



During the production of English sounds, the Punjabi speakers follow the tradition of the native English speakers to nasalize vowels more in anticipatory direction than carryover. As they have the same pattern in their L1 (Punjabi), so they made no exception.

5.2. CONTRASTIVE Vs CONTEXTUAL NASALIZATION

In Punjabi, the contrastively nasal vowels did not show statistically significant difference from contextually nasalized vowels, except /ɪ/. The contrastively nasal vowel /ɪ̃/ was depicting greater degree of nasality than the contextually nasalized vowel /ɪ/. (see figure 28)

Figure.5.5. The Δ(A1-P0) and Δ(A1-P1) for Given Contextually Nasalized Vowels (V) of Punjabi, Averaged across Speakers, Repetitions and Contexts (Regressive and Progressive). The Δ(A1-P0) and Δ(A1-P1) for Given Contrastively Nasal Vowels (Ṽ), Averaged across Speakers and Repetitions.

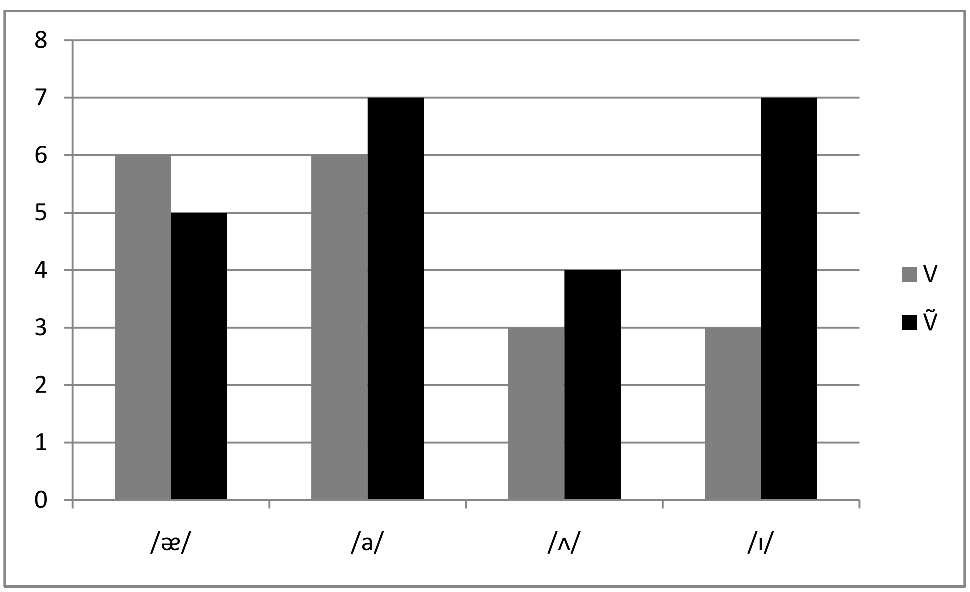
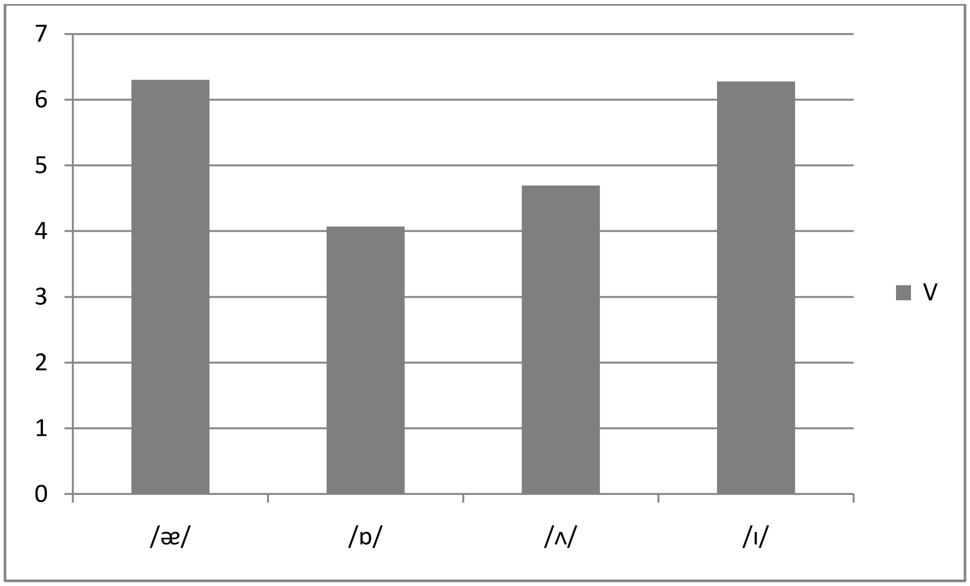


Figure.5.6. The Δ(A1-P0) and Δ(A1-P1) for English Contextually Nasalized Vowels (V), Averaged across Speakers, Repetitions and Contexts (Regressive and Progressive).



The Punjabi speakers nasalized the English vowel /ɪ/ with almost same degree of nasalization as in the Punjabi contrastively nasal vowel /ĩ/. So the degree of nasality was greater in Punjabi contrastively nasal vowel /ĩ/ and the English contextually nasalized vowel /ɪ/ than the Punjabi contextually nasalized vowel /ɪ/.

For the other two vowels / æ, ʌ/, there were no significant difference between the degree of nasality in the production of both Punjabi and English vowels. The speakers produced these vowels with almost same degree of nasalization in both Pakistani English contextual and Punjabi contrastive and contextual environments.

In Pakistani English, the speakers showed relatively greater nasality for the /ɪ/ and / æ/ vowels than /ɒ/ and /ʌ/ (see figure 29). In Punjabi, the /æ/, / æ̃/, /α/, /α̃/ and /ĩ/ vowels showed relatively more degree of nasality than the others. The short vowel /ʌ/ depicted relatively less degree of nasalization both in English and Punjabi (see figure 84).

As for as the effect of nasal consonant on the following or preceding vowels was concerned, all the three consonants /n, m, ŋ/ showed almost same effect on the vowel in Both Pakistani English and Punjabi language (see figure 5.7).

Figure.5.7.Average Δ(A1-P1) and Δ(A1-P0) across Punjabi Vowels, Speakers and Repetitions at the Middle of the Vowels.

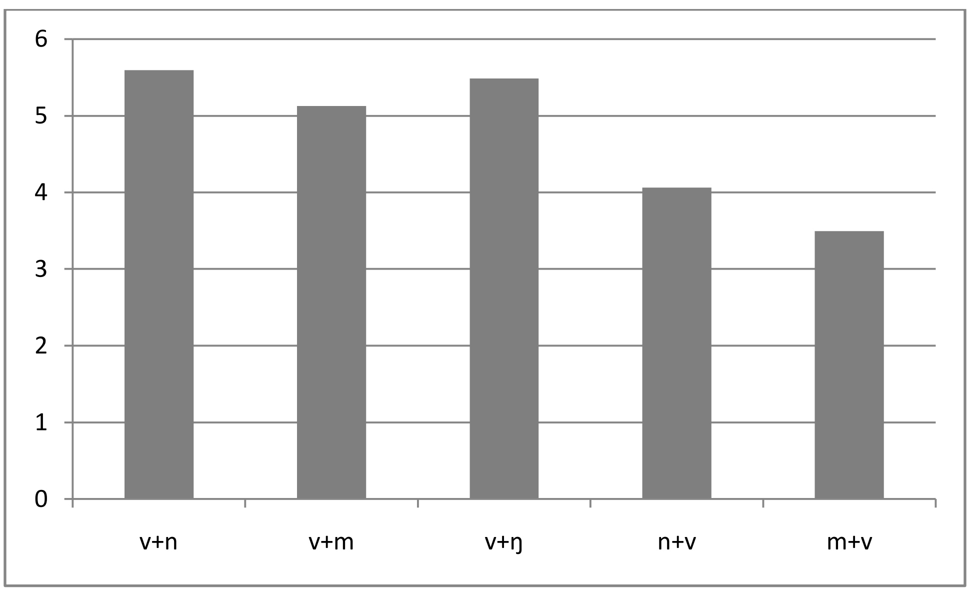
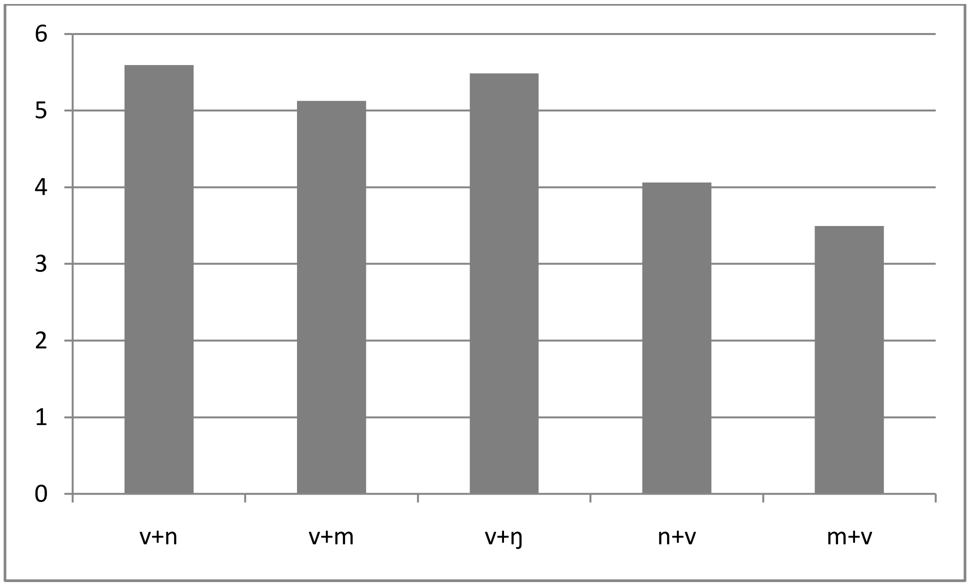


Figure.5.8.Average Δ(A1-P1) and Δ(A1-P0) across English Vowels, Speakers and Repetitions at the Middle of the Vowels.



5.3. INDIVIDUAL DIFFERENCES IN THE DEGREE OF NASALIZATION

The acoustic effects of nasalization differ across different speakers and vowels as well. Speakers differed on the basis of their velum lowering for the production of sounds. Different speakers showed different tendencies to nasalize vowels.

During the production of Punjabi data, speaker WS showed velum lowering throughout the vowels /α, æ, ɪ / in v+ m context, as for these three vowels, there was a significant difference between the measures taken at the onset, middle and the offset of vowels from the oral vowels. This reflected that the vowels /α, æ, ɪ / in v + m context was nasalized completely . He also nasalized /α̃, ĩ/ throughout the vowels, as nasalization was distinct in all the measured portions of the vowels.

While for Pakistani English vowels, the speaker WS showed a greater velum lowering for the vowel /æ/ in v+ m context than the other contexts. Furthermore, he nasalized the English vowel /ʌ/ completely in v+ n, v+ m and v+ ŋ contexts. As the vowel /ʌ/ showed the statistically significant degree of nasalization at all the portions of vowel for the given speaker.

The speaker QA showed the tendency to completely nasalize the Punjabi vowel /α/ in v+ n, v +m and v+ ŋ contexts. He also nasalized /α̃/ throughout the vowel. The Punjabi vowel /ʌ/ in v+ ŋ context and the vowel /æ/ in v+ n and v + m context showed the tendency to adopt nasality throughout the vowel for the given speaker (QA). During the production of English speech, the speaker QA nasalized the vowels /ʌ, æ / in n+ v context completely, reflecting a statistically significant difference between $(A1\text{-}P0)_O$ and $(A1\text{-}P0)_N$ values measured at the three portions of the vowels.

For Punjabi vowels, the speaker FA nasalized the vowels /α, æ / in v+ n and v+ m contexts completely, reflecting that the velum was lowered very earlier to allow coupling between the nasal and oral cavities , making the vowel take on nasality from even its onset . FA also nasalized the Punjabi vowel /α̃/ completely. On the other hand, he showed nasality effect for the English vowel /ʌ/ in n + v context, throughout the vowel.

The speaker MO nasalized the Punjabi vowel /α/ in v + ŋ context, the vowel /ʌ/ in n + v context, /ɪ/ in v+ m context, completely than the other contexts. Furthermore, he nasalized the Pakistani English vowel /ʌ/ in v+ m context, /ɪ/ in n+ v context, completely.

For the Pakistani English vowels, the speaker US did not nasalize any vowel in any context throughout its length. So, different speakers showed variation in their velum opening for the production of different vowels in different contexts.

There was also variation in taking on nasality for the vowels on the basis of different speakers and vowel quality. For Pakistani English vowels, the speaker Ws showed greater degree of nasality for the vowels / ʌ, æ, ɒ/. While the speaker QA nasalized /ɪ/ with a greater degree than the other three vowels. The speaker FA nasalized /ɪ, æ/ with higher degree than the other two vowels. The speaker MO showed greater degree of nasalization for the vowel /ɪ/ than the other three vowels. While the speaker US nasalized /æ, ɒ/ with higher degree than the other two vowels.

For Punjabi vowels, the speaker WS showed tendency to nasalize /æ, æ̃, ɪ/ with a great degree than the other vowels . The speaker QA nasalized /α, α̃, ĩ/ vowels greatly as compared to the other vowels. While the speaker FA showed a greater degree of nasality for /æ, α, α̃/ vowels and the speaker MO showed tendency to nasalize /æ̃, ĩ/ vowels with a great degree than the other vowels.

However, the speakers nasalized the long vowel /æ/ in both Pakistani English and Punjabi languages with a great degree . In Punjabi, long vowels /α, α̃, æ, æ̃/ showed greater nasality and the nasal vowel / ĩ/ was also nasalized with higher degree as compared to the others. In English and Punjabi, /ʌ/ vowel was pronounced with the minimum degree of nasalization by all the speakers except WS, he nasalized English vowel /ʌ/ with higher degree.

5.4. Comparison of nasalization patterns in Punjabi, Pakistani English and other varieties of English (AmE, Canadian)

This study depicted greater nasality in the high vowel /ɪ/ and the low vowel / æ / of English. It differed from the other verities of English as it showed the greater degree of nasality in high and low both vowels. Generally, in American English, low vowels are more prone to nasalization than high vowels (Bell- Berti, 1993; Krakow, 1995; Kluge, 2004). But in Canadian English, high vowels were nasalized with greater degree as compared to the low vowels (Rochet and Rochet, 1991).

The mean of Δ(A1-P0)) measured at the middle of the vowels, ranged from 3 db to 7 db for Punjabi (table 5.1) and from 4 db to 6 db for Pakistani English vowels (table 36). While the mean of Δ(A1-P1)) measured at the middle of the vowels, ranged from 3 db to 7 db for Punjabi and was of 6db for Pakistani English. Punjabi speakers showed almost similar values of Δ(A1-P0) and Δ(A1-P1) for Punjabi and English vowels.

Table.5.1.Average Δ(A1-P0) and Δ(A1-P1) across Speakers, Repetitions and Contexts (Regressive, Progressive) in the Middle of Punjabi Vowels.

Δ(A1-P0)				Δ(A1-P1)		
vowels	Mean	min.	max.	mean	min.	max.
/ɪ/				3	2	4
/æ/	6	4	9			
/ɑ/	6	4	8			
/ʌ/	3	2	5			
/ɪ̃/				7	2	9
/æ̃/	5	3	8			
/ɑ̃/	7	2	10			
/ʌ̃/	4	1	6			

Table.5.2.Average Δ(A1-P0) and Δ(A1-P1) across Speakers, Repetitions and Contexts (Regressive, Progressive) in the Middle of Pakistani English Vowels.

	Δ(A1-P0)			Δ(A1-P1)		
vowels	Mean	min.	max.	mean	min.	max.
/ɪ/				6	5	9
/æ/	6	5	8			
/ɒ/	4	2	6			
/ʌ/	5	3	6			

Chen described that Δ (A1-P1) ranged from 10 db to 15 db and Δ (A1-P0) ranged from 6 db to 8 db for American English. The values for Pakistani English and American English for vowels differed because of some causes. The studied vowels in this research were not the similar ones as studied by Chen. The values of Δ (A1-P1) and Δ (A1-P0) averaged across all the vowel portions (initial, medial and final) were stated in Chen's study. While in this study all the three portions of vowel were studied separately and the values measured at the middle of vowel were considered the most representitive of vowel's quality. The inter speaker variations also played an important role.

Chen placed the vowels in CVC and NVN contexts where C was standing for oral stop and N for nasal consonant. The results of her study depicted that the vowel in NVN context showed no difference of nasality at its onset, middle and offset. But in the present research, the studied contexts were CVC, CVN and NVC where the nasal consonant was not at the both boundaries of syllable. So, because of the difference of the contexts the direct comparison between Pakistani English and AME was not possible. The one possibility was to take the degree of nasality at the onset of vowels in NVC context and at the offset of the vowels in CVN context and compare them with the values stated by Chen. By doing so the maximum degree of nasalization could be compared.

As stated above, the analysis of data reflected that the Punjabi speakers showed greater tendency to nasalize vowels in anticipatory direction while the production of English sounds. Table 37 shows the maximum degree of nasalization in Pakistani English speakers' speech. The values measured at the offset of the Pakistani English vowels in CVN context were similar to those of AME.

Table.5.3.Average Δ(A1-P0) Values for Pakistani English Vowels, Measured at the Offset of the Vowels in CVN Context and at the Onset of the Vowels in NVC Context. The Values are Averaged across Repetitions and Speakers.

Δ(A1-P0)						
CVN				NVC		
vowels	**Mean**	**Min**	**Max**	**mean**	**Min**	**Max**
/æ/	8	5	12	7	5	10
/ʌ/	8	4	14	6	1	12

Table.5.4. Average Δ(A1-P0) Values stated by Chen (1997) for AME Vowels, averaged across Repetitions and Speakers.

Δ(A1-P0)			
Vowels	**Mean**	**Min**	**Max**
/æ/	8	4	16
/ʌ/	8	4	13

Chapter Six

SUMMARY

This study analyzed the nasalization patterns in Punjabi and Pakistani English through acoustic means. Punjabi is a language which has oral and nasal contrast for its vowels but English has only oral vowels. So the contrastive and contextual nasalization in Punjabi and the contextual nasalization in Pakistani English were studied. There is evidence in literature that the languages having contrastive nasality may limit the amount of contextual nasalization. This study intended to measure the amount of nasality in both contrastive and contextual environments in Punjabi vowels. The presence or absence of nasalization in /Ṽ/, VN (vowel+nasal consonant) and NV (nasal consonant+vowel) contexts, its degree and direction (anticipatory and carryover) were identified. For this purpose, five native Punjabi speakers were selected to collect data. After determining the degree and direction of nasality in Punjabi, the results were further compared to the nasalization patterns of Pakistani English. For Pakistani English, the vowels were studied in VN and NV contexts. They were compared to study the similarities and the differences between nasalization patterns of the speakers' L1 (Punjabi) and L2 (English).

The results of this study did not support the view that the nasality contrast for vowels limits the degree of contextual nasality. All the Punjabi oral vowels in nasal environment (NV, VN) showed almost the similar degree of nasalization as the nasal vowels, except /ĩ/. This vowel showed the greater degree of nasality than its oral counterpart /ɪ/.

The results depicted a greater degree of nasality for regressive nasalization than the progressive nasalization in both Punjabi and Pakistani English. In Pakistani English, there was a relatively higher degree of nasality for the /ɪ/ and /æ/ vowels than the /ɒ/ and /ʌ/. In Punjabi, the speakers showed relatively greater degree of nasalization for` /æ/, / æ̃/, /ɑ/, /ɑ̃/ and /ĩ/ vowels than the others. The short vowel /ʌ/ reflected relatively lesser degree of nasalization both in Pakistani English and Punjabi language. The mean of Δ (A1-P1) for Pakistani English speakers was 6 db and the mean of Δ(A1-P0) ranged from 4 db to 6 db. While, for American English, the mean of Δ(A1-P1) ranged from 10 db to 15 db and Δ (A1-P0) ranged from 6 db to 8 db. As far as the direction of nasalization was concerned, Pakistani English speakers used similar pattern of nasalization as the American English speakers. But they differed from the American English speakers on the basis of the degree of nasalization for the vowels of different quality. Pakistani English speakers nasalized both low and high vowels greatly while AME show greater nasality for low vowels.

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Appendices

APPENDIX A

MEASURED A1-P1 AND A1-P0 FOR PUNJABI VOWELS

The correlate A1-P0 measured at the initial point of Punjabi vowels averaged across repetitions for different contexts. The studied contexts were the oral (O), contrastively nasal (Ṽ) and contextually nasalized (N). The boldfaced and italicized numbers indicate $p<0.05$ between the Oral and nasal values.

/æ/ vowel

Values Measured at the Initial Portion of Vowel

speakers	O	Ṽ	N(v+n)	N(v+m)	N(v+ŋ)	N(n+v)	N(m+v)
WA	6.82	7.42	2.62	***3.1***	3.54	***0.02***	***0.28***
QA	8.92	6.52	***12.78***	***11.24***	9.56	***2.5***	***2.82***
FA	9.08	8.94	***3.02***	***6.56***	6.4	***2.64***	***4.08***
MO	11.28	11.52	8.18	6.04	***8.42***	***7.92***	***6.66***

Values Measured at the Middle Portion of Vowel

speakers	**O**	**Ṽ**	**N(v+n)**	**N(v+m)**	**N(v+ŋ)**	**N(n+v)**	**N(m+v)**
WA	9.6	***1.42***	***1.24***	***1.18***	***1.62***	***6.34***	***5.08***
QA	10.75	***6.62***	***1.84***	***3.28***	8.48	***3.78***	***6.478***
FA	12.82	***9.4***	***-1.98***	***8.76***	***1.16***	***6.16***	***6.92***
MO	14.78	9.12	***8.88***	10.62	***10.2***	13.66	15.08

Values Measured at the Final Portion of Vowel

speakers	**O**	**Ṽ**	**N(v+n)**	**N(v+m)**	**N(v+ŋ)**	**N(n+v)**	**N(m+v)**
WA	10.26	***2.16***	***-0.62***	***-0.1***	***-5.8***	8.34	9.58
QA	12.74	***2.2***	***0.36***	***1.38***	***-2.6***	13.04	9.88
FA	8.44	***1.72***	***-2.56***	***3.88***	***-6.4***	8.2	9.32
MO	14.8	***4.84***	***6.56***	***12.1***	***5.82***	10.6	13.02

/ɑ/ Vowel

Values Measured at the Initial Portion of Vowel

speakers	O	Ṽ	N(v+n)	N(v+m)	N(v+ŋ)	N(n+v)	N(m+v)
WA	8.88	***4.76***	6.26	***3.5***	6.88	***2.14***	***5.24***
QA	12.73	***5.32***	***8.2***	***6.08***	***9.48***	***1.22***	***0.96***
FA	11.82	***6.38***	***7.38***	***3.66***	8.14	***3.16***	***3.9***
MO	15.68	15.54	14.32	12.9	***12.9***	***9.02***	***11.46***

Values Measured at the Middle Portion of Vowel

Speakers	O	Ṽ	N(v+n)	N(v+m)	N(v+ŋ)	N(n+v)	N(m+v)
WA	8.22	***3.72***	***3.4***	***3.22***	4.38	7.78	7.02
QA	10.35	***-0.12***	***-0.04***	***-1.06***	***1.2***	***1.12***	***3.22***
FA	11.38	***1.98***	***3.08***	***1.08***	***-0.32***	***5.18***	***4.24***
MO	13.86	***11.5***	***9.54***	***9.48***	***8.52***	12.8	12.26

Values Measured at the Final Portion of Vowel

speakers	O	Ṽ	N(v+n)	N(v+m)	N(v+ŋ)	N(n+v)	N(m+v)
WA	9.1	***-0.46***	***0.64***	***1.4***	***-0.52***	***8.3***	9.62
QA	12.25	***0***	***2.44***	***1.06***	***3.34***	8.2	7.5
FA	9.84	***-0.58***	***2.5***	***-0.1***	***-3.94***	9.78	9.6
Mo	14.14	***9.02***	***9.26***	***10.2***	***8.16***	14.98	14.42

/ʌ/ Vowel

Values Measured at the Initial Portion of Vowel

speakers	O	Ṽ	N(v+n)	N(v+m)	N(v+ŋ)	N(n+v)	N(m+v)
WA	7.88	7.92	8.126	8.86	3.3	***0.72***	4.44
QA	12.32	11.04	11.26	12.54	***6.26***	***0.66***	***-2.12***
FA	10.52	8.66	7.78	6.7	6.88	***1.58***	***3.52***
MO	11.8	11.02	11.28	13.16	11.32	***7.78***	***7.64***

Values Measured at the Middle of Vowel

speakers	O	Ṽ	N(v+n)	N(v+m)	N(v+ŋ)	N(n+v)	N(m+v)
WA	8.62	5	***2.52***	***2.76***	***3.86***	5.44	7.28
QA	9.6	***4.04***	***7***	12.18	***4.62***	***4.2***	***2.02***
FA	11.52	***10.2***	10.46	10.52	***7.08***	***7.18***	***10.1***
MO	14.34	***10.3***	***9.82***	***9.76***	***8.34***	***12.2***	13.04

Values Measured at the Final Portion of Vowel

speakers	O	Ṽ	N(v+n)	N(v+m)	N(v+ŋ)	N(n+v)	N(m+v)
WA	7.58	***0.08***	***-0.42***	***-0.06***	***-2.78***	***4.12***	***7.66***
QA	11.32	***6.16***	***1.48***	***3.52***	***3.2***	10.4	8.62
FA	9.24	***4.8***	***4.18***	***3.06***	***-4.98***	9.26	10.02
MO	12.5	***8.32***	***7.4***	***7.3***	***8.22***	***10***	11.82

The correlate A1-P1 measured at the initial point of Punjabi vowels averaged across repetitions for different contexts. The studied contexts were the oral (O), contrastively nasal (Ṽ) and contextually nasalized (N). The boldfaced and italicized numbers indicate p<0.05 between the Oral and nasal values.

/ɪ/ Vowel

Values Measured at the Initial Portion of Vowel

speakers	O	Ṽ	N(v+n)	N(v+m)	N(v+ŋ)	N(n+v)	N(m+v)
WA	25.12	***20.1***	23.8	***19.9***	23.16	***18***	***16***
QA	25.98	24.28	30.78	25.18	31.66	25.38	***25.16***
FA	30.82	29.12	33.86	30	33.38	***27.2***	***26.16***
MO	25.68	25.72	23.68	***18.9***	26.74	***19.7***	***19.72***

Values Measured at the Middle of Vowel

speakers	O	Ṽ	N(v+n)	N(v+m)	N(v+ŋ)	N(n+v)	N(m+v)
WA	24.54	***15.7***	***20.4***	***18.5***	***20.2***	***21.1***	***21.4***
QA	34.75	***26***	31.44	26.96	30.74	29.73	30.8
FA	32.9	30.7	35.76	33.02	33.76	***29.4***	30.9
MO	25.9	***19.3***	***21.1***	***21.6***	22.38	***22.8***	***22.2***

Values Measured at the Final Portion of Vowel

speakers	O	Ṽ	N(v+n)	N(v+m)	N(v+ŋ)	N(n+v)	N(m+v)
WA	22.38	***17.4***	19.74	***15.9***	20.86	19.34	20.2
QA	31.35	20.76	***25.3***	***23.4***	28.6	30.44	29.08
FA	27.9	***22.6***	***22.4***	***23.2***	***24.5***	29.98	30.3
MO	24.58	***15.7***	***14.7***	***20.2***	***19.3***	25.68	24.54

Appendix B

MEASURED A1-P1 AND A1-P0 FOR PAKISTAN ENGLISH VOWELS

The correlate A1-P0 measured at the initial point of Punjabi vowels averaged across repetitions for different contexts. The studied contexts were the oral (O), contrastively nasal (Ṽ) and contextually nasalized (N). The boldfaced and italicized numbers indicate p<0.05 between the Oral and nasal values.

/æ/ Vowel

Values Measured at the Initial Portion of Vowel

speakers	**O**	**N(v+n)**	**N(v+m)**	**N(v+ŋ)**	**N(n+v)**	**N(m+v)**
WA	12.7	7.12	***8.12***	6.56	***3.86***	***1.22***
QA	10.18	9.92	9.78	8.34	***2.68***	***5.34***
FA	9.33	8.63	7.73	6.60	***0.33***	***4.40***
MO	11.45	11.5	11.8	10.96	***7.16***	***6.44***
US	6.88	4.62	7.04	4.36	***-1.26***	***-0.22***

Values Measured at the Middle of Vowel

speakers	O	N(v+n)	N(v+m)	N(v+ŋ)	N(n+v)	N(m+v)
WA	14.75	***1.72***	***2.9***	***4.94***	***10.08***	***6.44***
QA	14.04	***7.42***	***4.2***	***4.96***	***6.46***	8.7
FA	12.07	***1.93***	8.50	3.77	***4.20***	***6.00***
MO	12.775	***8.88***	***10.14***	7.48	12.52	15.02
US	8.22	***3.48***	***3.84***	***4.18***	***2.98***	***0.98***

Values Measured at the Final Portion of Vowel

speakers	O	N(v+n)	N(v+m)	N(v+ŋ)	N(n+v)	N(m+v)
WS	13.35	***1.04***	***2.56***	***1.76***	15.44	14.18
QA	13.56	***6.26***	***5.22***	***1.28***	***9.58***	11.46
FA	9.97	***-2.50***	***4.00***	0.80	11.57	10.90
MO	13.35	***7.8***	***5.78***	***7.28***	12.58	12.9
US	3.24	***-2.16***	***-2.16***	***-0.74***	5.62	3.98

/ɒ/ Vowel

Values Measured at the Initial Portion of Vowel

speakers	**O**	**N(v+n)**	**N(v+m)**	**N(v+ŋ)**	**N(n+v)**	**N(m+v)**
WS	10.4	7.88	13.12	7.42	***2.96***	***5.52***
QA	13.24	14.22	13.58	10.7	***6.58***	***8.28***
FA	10.10	9.23	10.40	9.23	***4.07***	***5.97***
MO	12.9	12.34	12.48	13.32	11.66	13.7
US	8.28	4.4	9.16	5.9	***5.12***	***4.26***

Values Measured at the Middle of Vowel

speakers	**O**	**N(v+n)**	**N(v+m)**	**N(v+ŋ)**	**N(n+v)**	**N(m+v)**
WS	15.46	***3.74***	***5.04***	***9.5***	***8.25***	***6.76***
QA	15.6	13.76	11.32	7.38	13.92	14.28
FA	10.47	***4.80***	***5.37***	***8.67***	10.47	9.57
MO	16.22	***11.6***	10.94	15.88	16.58	15.66
US	9.28	***1.44***	7.62	***4***	8.56	8.28

Values Measured at the Final Portion of Vowel

speakers	**O**	**N(v+n)**	**N(v+m)**	**N(v+ŋ)**	**N(n+v)**	**N(m+v)**
WS	15.86	***0.2***	***4.6***	***6.02***	10.58	12.48
QA	15.36	***6.08***	***7.9***	***4.88***	14.62	14.38
FA	9.63	***2.97***	***4.00***	***1.67***	9.40	9.53
MO	14.62	***9.18***	13.1	10.44	11.72	14.12
US	6.5	***-2.72***	2.82	***-1.72***	4.64	5.4

/ʌ/ Vowel

Values Measured at the Initial Portion of Vowel

speakers	**O**	**N(v+n)**	**N(v+m)**	**N(v+ŋ)**	**N(n+v)**	**N(m+v)**
WS	13.36	***7.72***	***7.86***	***9.04***	***-0.42***	***2.76***
QA	11.68	13.46	9.12	10.1	***8.1***	***5.76***
FA	6.90	10.30	2.63	6.47	***5.60***	5.47
MO	13.26	13.17	***9.54***	11.72	***8.60***	***9.94***
US	7.64	***4.14***	2.9	4.16	***-1***	***-1.32***

Values Measured at the Middle of Vowel

speakers	O	N(v+n)	N(v+m)	N(v+ŋ)	N(n+v)	N(m+v)
WS	14.44	***2.54***	***3.82***	***4.96***	***4.12***	***9.14***
QA	13.84	12.68	10.12	***10.02***	***11.08***	9.06
FA	10.73	13.13	5.93	9.53	***7.13***	8.77
MO	13.4	***7.60***	***9.6***	***8.26***	13.76	14.28
US	8.88	***0.3***	***1.8***	5.14	***2.36***	***3.95***

Values Measured at the Final Portion of Vowel

speakers	O	N(v+n)	N(v+m)	N(v+ŋ)	N(n+v)	N(m+v)
WS	15.16	***-0.2***	***1.16***	***2.22***	17.12	16.9
QA	13.7	***9.12***	***7.64***	***7.12***	***7.88***	13.02
FA	9.50	9.27	***0.90***	5.83	***7.50***	6.07
MO	14.48	***7.5***	***8.04***	***5***	14.64	13.98
US	5.86	***-6.06***	***-2.66***	***-1.4***	4.95	7.325

The correlate A1-P1 measured at the initial point of Punjabi vowels averaged across repetitions for different contexts. The studied contexts were the oral (O), contrastively nasal (Ṽ) and contextually nasalized (N). The boldfaced and italicized numbers indicate p<0.05 between the Oral and nasal values.

/ɪ/ Vowel

Values Measured at the Initial Portion of Vowel

speakers	**O**	**N(v+n)**	**N(v+m)**	**N(v+ŋ)**	**N(n+v)**	**N(m+v)**
WS	28.33	27.98	28.30	27.48	***19.88***	***22.58***
QA	27.00	28.66	29.24	28.92	***22.20***	***19.50***
FA	42.43	33.60	41.57	37.30	***27.23***	***28.97***
MO	29.25	28.68	27.60	28.24	***22.30***	***19.92***
US	26.23	19.93	12.98	26.98	***13.90***	20.63

Values Measured at the Middle of Vowel

speakers	**O**	**N(v+n)**	**N(v+m)**	**N(v+ŋ)**	**N(n+v)**	**N(m+v)**
WS	29.65	***23.98***	24.55	***21.48***	***24.30***	***24.65***
QA	30.24	26.72	28.18	***27.14***	27.18	25.70
FA	43.50	36.07	32.67	***27.03***	***36.13***	34.00
MO	31.13	***21.38***	***18.92***	***19.76***	***25.78***	25.28
US	24.95	***24.03***	***22.30***	19.94	20.95	22.23

Values Measured at the Final Portion of Vowel

speakers	**O**	**N(v+n)**	**N(v+m)**	**N(v+ŋ)**	**N(n+v)**	**N(m+v)**
WS	26.68	***22.13***	***22.10***	***20.85***	25.70	25.88
QA	34.34	***23.54***	***23.34***	***24.60***	34.30	35.18
FA	39.83	35.67	29.33	***22.10***	34.43	37.27
MO	30.20	***20.28***	***18.38***	***18.82***	***24.16***	29.22
US	26.80	***11.68***	***18.98***	12.68	25.15	26.23