UNIVERSITY OF ALBERTA

The Status of Voiceless Nasals in Ikema Ryukyuan

BY

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A THESIS

SUBMITTED TO THE FACULTY OF ARTS

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF ARTS

DEPARTMENT OF LINGUISTICS

And

DEPARTMENT OF EAST ASIAN STUDIES

EDMONTON, ALBERTA

April, 2016

UNIVERSITY OF ALBERTA

FACULTY OF ARTS

The undersigned certify that they have read and recommend to the Faculty of Arts for acceptance, a thesis entitled *The Status of Voiceless Nasals in Ikema Ryukyuan*, submitted by Catherine Ford in partial fulfillment of the requirements for the degree of Bachelor of Arts.

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ABSTRACT

Human production and perception of language, although studied for decades, is largely misunderstood. Furthermore, not all sounds in human language have been studied extensively. Typologically rare sounds arguably lack reliable documentation and research. One such sound is voiceless nasals. Debate as to the degree of voicelessness, method of articulation and general perceptibility abound concerning the extant careful speech based research (Bhaskararao & Ladefoged, 1991, Ohala & Ohala 1993). The current study evaluates the acoustic qualities of voiceless nasals in Ikema, a dialect of the Ryukyuan language Miyako spoken on Japanese islands near Taiwan.

Data collected from elicitation sessions was analyzed for Ikema's phonemic nasals /n̥, m̥, n, m/. Speech data consisted of minimal pairs produced in spontaneous sentences chosen by the speakers, maximizing natural language quality. Target sounds were segmented in Praat and analyzed for voiced and voiceless nasal portions. Initial analysis revealed voicing throughout the target sounds when found word or phrase medially, or word or phrase finally, leading to analysis of breathy voicing state quality using cepstral peak prominence (CPP). The segments were compared to voiceless nasals and modal nasals found in the language. Analysis revealed significantly higher CPP for target voiced sounds than modal sounds, suggesting an allophonic relationship between voiceless nasals and breathy nasals in Ikema.

Detailed knowledge of voiceless nasal articulation in natural speech will help create a more accurate understanding of Ikema's sound system, extending to our knowledge of Miyako and its relative Japanese. This research may also illustrate variable articulations of voiceless nasals, contributing to our efforts to describe human phonetics as a whole.

ACKNOWLEDGEMENTS

I would like to thank my supervisors Dr. Benjamin V. Tucker and Dr. Tsuyoshi Ono for their support and patience. Their honesty and friendship helped inspire my passion for research and will continue to motivate me in the future. I would also like to thank my family and friends for their positivity and enthusiasm in my pursuit of linguistic research, even though they still have no idea what I'm doing. In particular I want to thank Honoka for helping me believe I would at least come home with "some" data. Lastly, I would like to extend my warmest gratitude to the people of Ikema and Miyako for caring for me these past two years, and sharing their culture so openly with me. Specifically, I'd like to thank Ms. Hiromi Maedomari and Mr. Motoi Gushiken for involving me so intimately with their own families and for their tireless patience. Without them, this research would not have been possible.

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CHAPTER I. Voiceless Nasals and Ikema Ryukyuan

Acoustic analysis of phonemes found in the world's languages has been a thriving area of linguistic research for the past century. Striving to understand the human sound inventory has helped discover relationships between certain types of sounds both within and across languages. In this way, phonetics acts as a base for language comprehension, and the variation both possible and impossible. Through the research efforts of many, it has been noted that some sounds are more common than others. Typologically rare phonemes consequentially lack opportunity to be studied at the level of those found commonly across languages. Without their exploration, human language articulation cannot be fully understood, leading to holes in theories of production, perception, and how language may change over time. The subject understudy in this paper attempts to provide some of this missing information concerning rare sounds, particularly focusing on voiceless nasals.

Voiceless nasals are found in only a handful of languages worldwide, and seem to occur in isolation within language families. At present, voiceless nasals are known to occur in languages such as Romanian, Icelandic, and Burmese, all of which are completely unrelated. Some familial connections can be made, as with Burmese and Angami, which are both rich in voiceless nasals and belong to the Tibeto-Burman family. However, the majority of instances seem to be unique. One language that lacks in-depth description is Miyako Ryukyuan, a dialect of which is said to contain phonemic voiceless nasals. This dialect, Ikema, is unique to other dialects of Miyako and seemingly other Ryukyuan languages in this respect. While voiceless nasals have been documented in the Ryukyuan language Ōgami (Pellard 2010), their relationship appears to be allophonic with voiced nasals. Thus, studying Ikema provides a unique opportunity to observe the phonemic nature of voiceless nasals.

This paper will discuss a variety of studies that lead to the conclusion of Ikema having an allophonic variation between voiceless and breathy nasals. The first chapter will give an overview of voiceless and breathy nasals, and the language context of Ikema. Chapter 2 will discuss initial observations based on pre-existing data from a single speaker. This analysis was used as a basis for the methodology of the production study. The production study is described in detail in Chapter 3, where nasal data is collected from 5 speakers and analyzed for voicelessness and breathiness. Chapter 4 discusses a small perception task where a few speakers were asked to perform a discrimination task between synthesized non-words containing the target sound. Chapter 5 provides a summary and overall conclusions of the studies described.

1.0 Phonemic Background

Miyako is a Ryukyuan language spoken on remote islands between Okinawa and Taiwan (Figure 1). Politically, these islands are apart of Japan within Okinawa Prefecture, thus the modern population also speaks Japanese. The Ikema dialect speaker population is split between Ikema proper, the community Nishihara on Miyako Island, and the community of Sarahama on Irabu Island (Figure 2). These communities are within relatively close proximity, having recently gained inter-island road access. In total an estimated 2000 people speak the Ikema dialect (Hayashi 2010). The majority of speakers are over the age of 60, the younger population largely monolingual Japanese speakers. Accordingly, Ikema is considered “definitely endangered” by the UNESCO *Atlas of the World’s Languages* (Iwasaki & Ono, 2009).

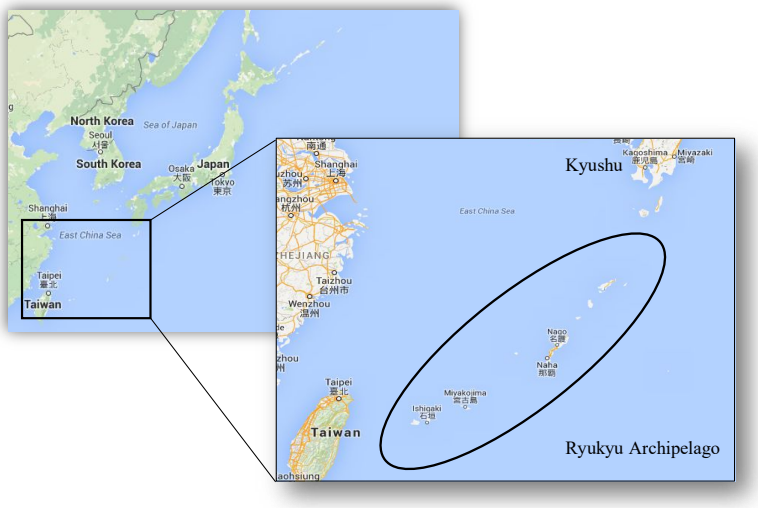

Figure 1: Ryukyu Archipelago, "Okinawa Prefecture", situated between Kyushu, Japan and Taiwan.[1]

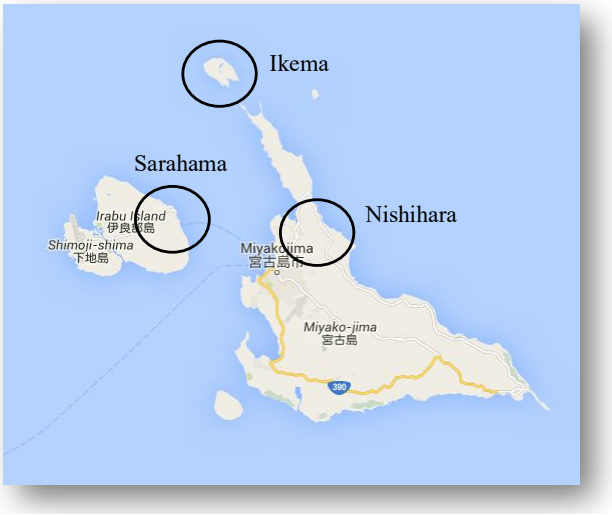

Figure 2: The Miyako Islands, Miyako-jima, Ikema-jima, and Irabu-jima

While no detailed acoustic studies on the phonetics of Ikema have been conducted, Hayashi's dissertation (2013) is the first of any grammatical sketches published concerning

[1] Figures 1 and 2 taken with permission from Honoka Takei's dissertation entitled *An Investigation of Direct Object Coding System in Ikema dialect of Miyako* (2016)

Ikema. This account also gives an auditory description of the phonetic inventory. It should be noted, however, that the majority of Hayashi's speakers are from the Nishihara community, and may not fully capture the phonetic qualities of the other Ikema communities. For example, one discrepancy is the vowel found at the end of the word "thank you", pronounced as /sɨdigahou/ in Nishihara, and /sɨdigahu/ on Ikema Island. For the purposes of this study, all data was collected on Ikema Island, and thus will not necessarily match Hayashi's descriptions.

Consonants

	Bilabial	Labio-dental	Alveolar	Palato-alveolar	Palatal	Velar	Glottal
Plosive	p b		t d			k g	
Nasal	m		n̥ n				
Affricate			ʦ dz	ʧ ʤ			
Fricative	ɸ	v	s	ʃ			h
Trill/Flap			ɾ				
Approximant	w				j		

Table 1: Phonemic consonant inventory of Ikema. At present, there are still many discrepancies concerning the status of each sound in Ikema. This table represents my own understanding of the sound system after consulting with researchers in this area and from my own observations.

Table 1 provides the phonemic consonant inventory of Ikema. The dialect has a voicing distinction for stops but seems to lack it for fricatives. Similar to Japanese, the only rhotic in Ikema is the alveolar flap /ɾ/. As well, this dialect contains the bilabial voiceless fricative /ɸ/, although Hayashi (2013) claims to have observed the labio-dental fricative /f/ in Nishihara as well.

The phonemic nasals in Ikema include the bilabial /m/, alveolar /n/, and their voiceless counterparts /m̥/ and /n̥/. These voiceless nasals seem to be affected by their surrounding environment, the bilabial occurring before bilabial consonants, and the alveolar occurring

elsewhere. This would suggest that the two voiceless nasals are allophones. Thus, it seems logical to conclude that there are two voiced phonemic nasals /m/ and /n/, and one voiceless nasal phoneme /n̥/ with the bilabial allophone /m̥/. Example (1) provides a minimal pair for the two voiced phonemes, and example (2) for the voiceless phonemes and their voiced counterparts.

(1) [mii] – to see [nii] – to boil

(Hayashi, 2013. p.37)

(2) [m̥mii] – to draw water [mmii] – to ripen

[n̥na] – rope [nna] – snail

(Hayashi, 2013. p.37)

The velar nasal /ŋ/ is also present within the language, but seems to occur only before other velar consonants. In the absence of minimal pairs, /ŋ/ is best judged as an allophone of /n/. There is also likely the uvular nasal /ɴ/ appearing as a word final allophone.

The basic syllable structure of Ikema is a CV pattern. Other possibilities include CVN, as in *biki**dun*** "man", and NCV as in *nsɨ* "north". In NCV environments, the nasal is determined by the following consonant. Bilabial nasal /m/ appears before labial consonants, /n/ appears before alveolar and palatal consonants, and /ŋ/ before velar consonants, as is illustrated in example (3) below.

(3) [mbasɨ] – to grow (hair, etc)
[nta] – ground
[ŋgamasɨ] - noisy

(Hayashi, 2013. p.37)

Vowels

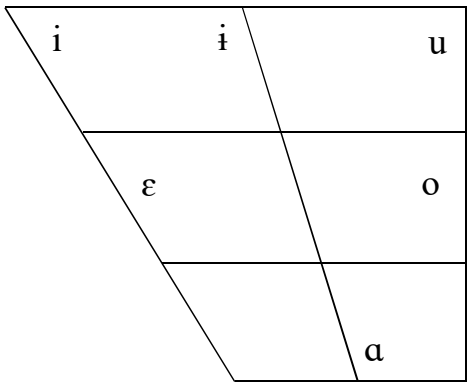

Figure 3: Vowel space of Ikema

Traditionally, Ikema is thought to only have the four vowels, /i, ɨ, a, u/, however /ɛ/ and /o/ are found throughout the language as well. According to Hayashi these sounds are only found in clause-final particles such as *do:* (similar to Japanese *yo*), or as interjections within a conversation, such as /ɛ:/, meaning 'yes'. These sounds are also found in Japanese loan words, such as *gakko:* 'school'. Whether these sounds are entirely the result of Japanese influence and borrowing is difficult to tell, however more historical research may shed light on this aspect of the language.

Vowels are distinguished in terms of length in Ikema. This seems to be more common for tense vowels, occurring as either short or long, as can be seen in example (4).

(4) [kuba] – fountain palm [kuuba] – come (command form)

[tʃɨtʃi] – moon [tʃɨtʃɨɨ] – a type of sea cucumber

(Hayashi, 2013. p.38)

Cardinal vowels may also be articulated as lax without altering meaning. Thus, similar to English, Ikema may have a length distinction that is both quantitative and qualitative, allowing for the possibility of lax vowels. At present this appears to be true for both long and short vowels, and is presumably based on speaker preference. Vowel devoicing is also common within Ikema, and is seemingly possible for any short vowel preceded by a voiceless consonant.

This has been a brief description of the current understanding of the phonemic inventory of Miyako Ikema. The next section will discuss the sound understudy, voiceless nasals, in greater detail.

1.1 Ikema and Voiceless Nasals

Voiceless nasals, being typologically sparse among the world's languages, are a largely understudied phenomenon, producing much debate about their phonetic qualities. Whether they are completely voiceless and by extension whether the acoustic and aerodynamic information available allows interlocutors to perceive potential variants phonemically is often disputed. Most analyses reveal voiceless nasals comprised of both voiceless and voiced segments, particularly those phonemically distinguished for place of articulation. Without this voiced segment, place of articulation is likely impossible to perceive, based on the differing aerodynamic principles of the nasal and oral cavities (Ohala & Ohala 1993). An initial analysis of pilot data collected from a single Ikema speaker will be analyzed, followed by a description of the larger study based on these early findings.

As previously mentioned, Hayashi's dissertation (2013) briefly describes the auditory nature of phonemic voiceless nasals in Ikema, specifically focusing on the Nishihara community.

The phonemic nasals in Ikema form voiced and voiceless phonemic pairs, [m, m̥] and [n, n̥]. In her dissertation, Hayashi demonstrates minimal pairs between the voiced and voiceless sounds, reinforcing the idea of phonemic variation. Examples are as follows: [m̥mii] “to draw water” and [mmii] “to ripen”, and [n̥na] “rope” and [nna] “snail”. It should also be recognized that voiceless nasals in Ikema always occur before a voiced nasal of the same place of articulation. These initial observations suggest that the voiceless nasals in Ikema contain a final voiced segment, likely allowing for ease of place of articulation perception, as was claimed by Ohala & Ohala (1993). These findings suggest voiceless nasals much like those documented in Burmese, which Danstuji (1986) described as having an initial voiceless “friction” portion followed by a voiced “nasal murmur” leading into a vowel. These two segments allow for phonemic variation, the former distinguishing sounds from their voiced counterparts, and the latter making each place of articulation perceivable (Bhaskararao & Ladefoged, 1991).

However, Bhaskararao & Ladefoged (1991) suggest that voicing does not necessarily need to be present for place of articulation to be perceived. Analyses of the three voiceless nasals present in the Tibeto-Burman language Angami shows all three being entirely voiceless while phonemically distinguished by speakers. At first this seems to contradict the claims of Ohala & Ohala (1993), who explain that voicing occurs in these sounds because of the relatively low level of turbulence created through the nasal cavity, thus making purely voiceless nasals difficult to perceive. Aerodynamic analysis of the airflow of Angami voiceless nasals, however, shows a combination of oral and nasal airflow throughout the sound. With this, speakers are able to vary the degree of frication created; thus their perceivable differences may be based on place of articulation alone. This finding suggests that there are multiple ways voiceless nasals may be articulated and perceived.

Differences in perception are further highlighted by studies within other areas of linguistics, including historical, child language acquisition and phonetic documentation. Much of the current research suggests a close relationship with voiceless nasals and fricatives. Ohala & Ohala (1993) claim voiceless nasals can be classified as [-sonorant], their voiced variants largely accepted as [+sonorant]. This phonological proposition centers on the typical environment in which voiceless nasals are found, often clustered with voiceless fricative /s/. Examples of this are found in Burmese (Dantsuji, 1986) and Romanian (Tucker & Warner, 2010). Children learning English are also often reported replacing /sn/ and /sm/ consonant clusters with voiceless nasals of the same place of articulation, supporting the claims made by Ohala & Ohala (1993). However, the current trend in Ikema suggests a very different perception of these sounds, only ever being paired with a voiced nasal. Additionally, pairs such as /nndi/ and /n̥ndi/, both being acceptable forms of "yes", may provide evidence for a stronger perception of nasal quality by Ikema speakers. If the voiceless "friction" portion of voiceless nasals was perceived as the primary auditory cue, then we might expect variations such as /sndi/ to occur. However, because the voiced nasal alternative /nndi/ is accepted, it suggests that Ikema nasals are likely not entirely voiceless and require voicing in order to be perceived by listeners. It should also be mentioned that studies on perception such as those by Ohala & Ohala (1993) were based on production. No true perception study has been conducted on voiceless nasals, leading to the conclusion that little is known about how speakers perceive these phonemes.

1.2 Breathy Nasals

Results from the observations discussed in Chapter 2 suggest that the voiceless nasals in Ikema appear with voicing throughout in connected speech, and in word-medial and final

positions. Despite this, there is reason to believe that these nasals differ from modal nasals in the language. Speakers are very much aware of their differing articulation, countless times explaining this to me of their own volition. Spectrograms also reveal differences between modal nasals and the target sound despite word position. Because of the voicing, this sound cannot be considered a voiceless nasal in this context. One other possibility is variation of voicing state, leading to breathy nasals.

Cross-linguistically, breathy nasals and voiceless nasals seem to appear in the same language groups. Sumi, a Tibeto-Burman language, is related to Angami, a language with voiceless nasals. Unlike Angami, Sumi lacks voiceless nasals, having a breathy-modal contrast instead. Using airflow and laryngeal analyses, Harris (2010) illustrated many differences between modal and breathy nasals in Sumi. Sumi nasals are represented in roman orthography as "mh", and were shown to realize the breathy portion in the last half of the sound. The initial portion is similar to modal phonation in this language. The airflow data collected by Harris gave results strikingly similar to Bhaskararao & Ladefoged (1991) who analyzed Angami's breathy nasals. These findings give weight to the hypothesis that Ikema's non-modal nasals could be breathy in some instances and voiceless in others, leading to an allophonic analysis of the target sound.

Gordon & Ladefoged (2001) present multiple acoustic differences between breathy and modal nasals. Breathy nasals tend to show more noise energy in both the waveform and the spectrogram, as compared to modal nasals that should lack turbulence. This noise decreases the clarity of individual glottal pulses that are normally visible in a modal voicing state. Transitions also become fuzzy because of the wider bandwidth of formants. The article also presents phonetic measures of breathy nasals that can be used to distinguish them acoustically from modal

nasals. Measuring the spectral tilt, the degree to which intensity decreases as frequency increases, can indicate if a nasal is breathy. Sounds produced with breathy voicing state generally have higher spectral noise in the high frequencies because of a leakage of air through the glottis and a lower acoustic intensity than modal sounds. The spectral tilt can compare the amplitude of high frequency noise, helping determine whether a sound is breathy or not. If the sound is breathy, there should be a steep fall off of amplitude at higher frequencies.

CHAPTER II. Initial Observations

The following description will discuss initial observations of pre-existing data of what are believed to be voiceless nasals in Ikema. Hypotheses generated will be tested using the data collected for the main study, providing evidence for the capacity in which voiceless nasals are believed to be present within Ikema.

2.0 Methods

Data was collected from a 63-year-old male speaker in August 2015 on Ikema Island by Dr. Tsuyoshi Ono for the purposes of this study. The recordings were made using a Sennheiser System K9 microphone and a Marantz PMD660 recorder in an indoor setting. The speaker was asked to produce the target words (see Appendix A) in two prescribed sentences, having the word appear phrase initially and phrase medially. An example of these sentences is shown below in Example 1, where the target word is presented in bold.

(1) hitoshi ga **hnna** ti aitai
hitoshi TOP rope QUOT say.PAST
"Hitoshi said rope."

hnna ti aitai
rope QUOT say.PAST
"(he) said rope."

The recordings were viewed in Praat to observe prominent acoustic cues present in the spectrograms of target words such as voicing, noise amplitude, nasal formants and duration. These measures allowed a preliminary assessment of whether the target sound is voiceless and how it may vary in different word positions. Words were segmented within the program. Word-

initial voiceless nasals were segmented from the beginning of the nasal formant to the start of voicing. Those found word-medially could not be distinguished from the following voiced nasal, and were segmented with the voiced nasal. Word-final voiceless nasals were measured as the section of the nasal where amplitude significantly drops, demonstrating that it was thought early on in the research process that these sounds may involve the manipulation of acoustic qualities other than voicing.

2.1 Analysis & Results

Judging from the spectrograms (Figures 4 & 5), only the word-initial items appear to be voiceless. The word-final segments drop in amplitude significantly from the preceding vowel and the following voiced nasal, but show voicing throughout. Without listening to the recordings, the word-medial sounds could be analyzed as a voiced nasal that is simply longer than most.

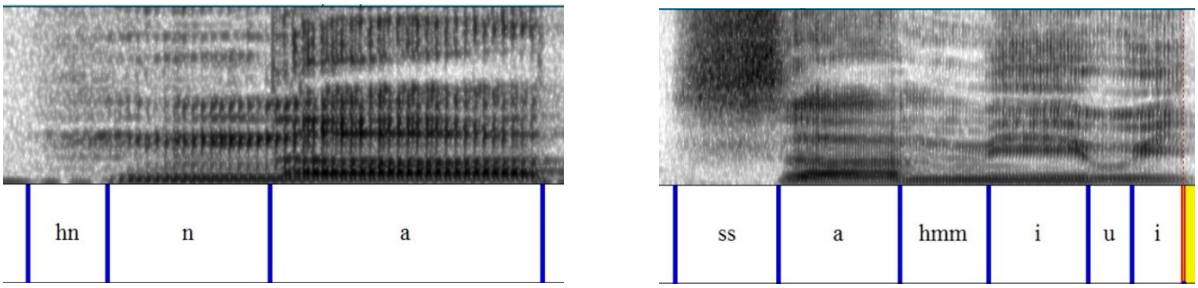

Figure 4: Spectrogram of the word *hnna* “rope” and *ssahmmiui* “going numb”

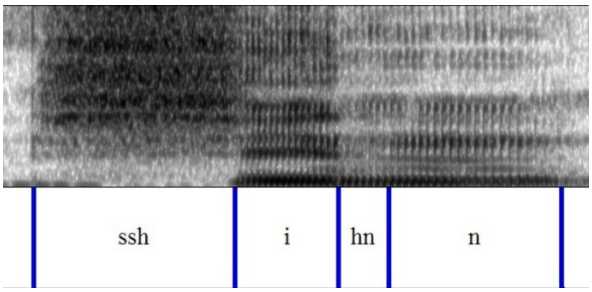

Figure 5: Spectrogram of the word *sshihnn* “to step on coral”

Speakers do perceive these sounds as distinct from voiced nasals. Evidence for this can be found in orthographic representations. Some Ikema speakers write using either *hiragana*, *katakana*, or a mixture of both to account for a single alphabet’s poor representation of the Ikema sound system. If the writer uses only one alphabet and is asked to write a word containing a voiceless nasal, they say it is impossible and settle for the Japanese voiced character “n” (ん or ン). If using a mixture, the most popular method is to primarily use *hiragana* with the voiceless nasal represented using *katakana*, such as in *hnna* “rope” (ンな). Other clues to the target sound being phonemically distinct from the voiced nasal is the prevalence of minimal pairs, and their lack of acceptance for target words produced without the “voiceless” segment. While these sounds may not be voiceless, they are undoubtedly distinct from modal voiced nasals in the language.

The most plausible explanation for how these sounds may differ from voiced nasals is that they are produced with a breathy voicing state. This would reduce the overall amplitude of the sounds and produce spectrograms with broadband formants because of the increased frication; a possible explanation for what is seen in Figure 5. Breathiness can also have an affect on preceding vowels, producing a less well-defined vowel transition often present in modal nasals, all while still producing a voiced sound (Gordon & Ladefoged 2001). With these breathy features in mind, the main study attempted to observe whether breathy voicing state was an

adequate explanation for the variation present in target sound articulation. Judging based on these isolated word samples, it would seem likely that voiceless nasals only occur in careful articulation contexts, and even then only word-initially. Word-medially and finally, the voiceless nasals are influenced by preceding vowels, making them appear with voicing throughout. As Ikema is based on a CV mora structure, all nasals, unless produced phrase-initially, will be preceded by a sonorant. In rapid speech word boundaries tend to disintegrate leading to co-articulation effects across words. Therefore, it is hypothesized that voiceless nasals will become breathy nasals in rapid speech regardless of word position.

CHAPTER III. Production Study

3.0 Methods

Participants

Data was collected from 6 speakers (5 male, 1 female) over the age of 56 during December 2015. One male speaker had to be excluded during analysis, as he seems to have lost the voiceless nasal phonemic distinction likely from Japanese influences. The four male speakers included in the analysis were born on the island and grew up speaking Ikema. Their ages range from mid 50's to mid 70's. The female speaker is in her 60's and was raised by her grandmother who was from Nishihara, and may have some variation in her pronunciation as a result.

Procedure

Recordings were made in person on Ikema Island, either at the local community centre or in the speaker's home depending on their physical mobility. When able, recordings were made using a Countrymax Associates Inc. Isomax head-mounted microphone. Some speakers found this uncomfortable, however, in which case the Sennheiser System K9 microphone was used. A Marantz PMD660 recorder was used in every recording. The methodology used to collect the data for initial observations was slightly altered, as speakers expressed that the prescribed sentences were unnatural. In order to capture each word as accurately as possible, speakers were asked to produce sentences of their own using the target word. Speakers were also asked to produce the words in isolation. Elicitation sessions were conducted entirely in Japanese, asking speakers to translate from Japanese to Ikema in order to avoid any influence the researcher's pronunciation may have on the target words. In total, 26 target words were elicited from each speaker (14 voiceless nasal words, 14 minimal or near-minimal pair words). Occasionally

speakers were unable to remember a word, or produced a different word than expected. Thus, not all 28 words were able to be collected from each speaker. In total, 285 target utterances and 248 minimal pair words were collected for analysis.

3.1 Analysis

Target words and minimal/near-minimal pair words were segmented in Praat as they were for the pre-existing data. Target sounds that had voicing throughout were segmented with the following voiced nasal. As was to be expected, the previously assumed voiceless nasals that appear word-medially and word-finally had voicing throughout. Interestingly, when produced in the sentences speakers created, word-initial voiceless nasals also often appeared with voicing throughout. The target words were, however, vastly different from minimal pairs despite this apparent voicing. The spectrograms of the target sounds, *hmmi* and *hmmu* in Figure 6, show a significant decrease in amplitude and an increase in noise as compared to the modal voiced nasals in the minimal pair word *mmiui*.

Once segmented, a Praat script was used to extract data on duration and breathy voicing state. The duration of voiceless nasal portions and voiced nasal portions were compared, between minimal pairs and within target words. In order to measure breathy voicing state, the amplitude measure cepstral peak prominence (CPP) was used. The CPP measure was shown by Samlan & Story (2011) to mark perceptually different voicing states between breathy and modal nasals, similar to the properties described by Gordon & Ladefoged (2011). A high CPP measure should reflect the high noise amplitude expected, if these target sounds are indeed breathy nasals.

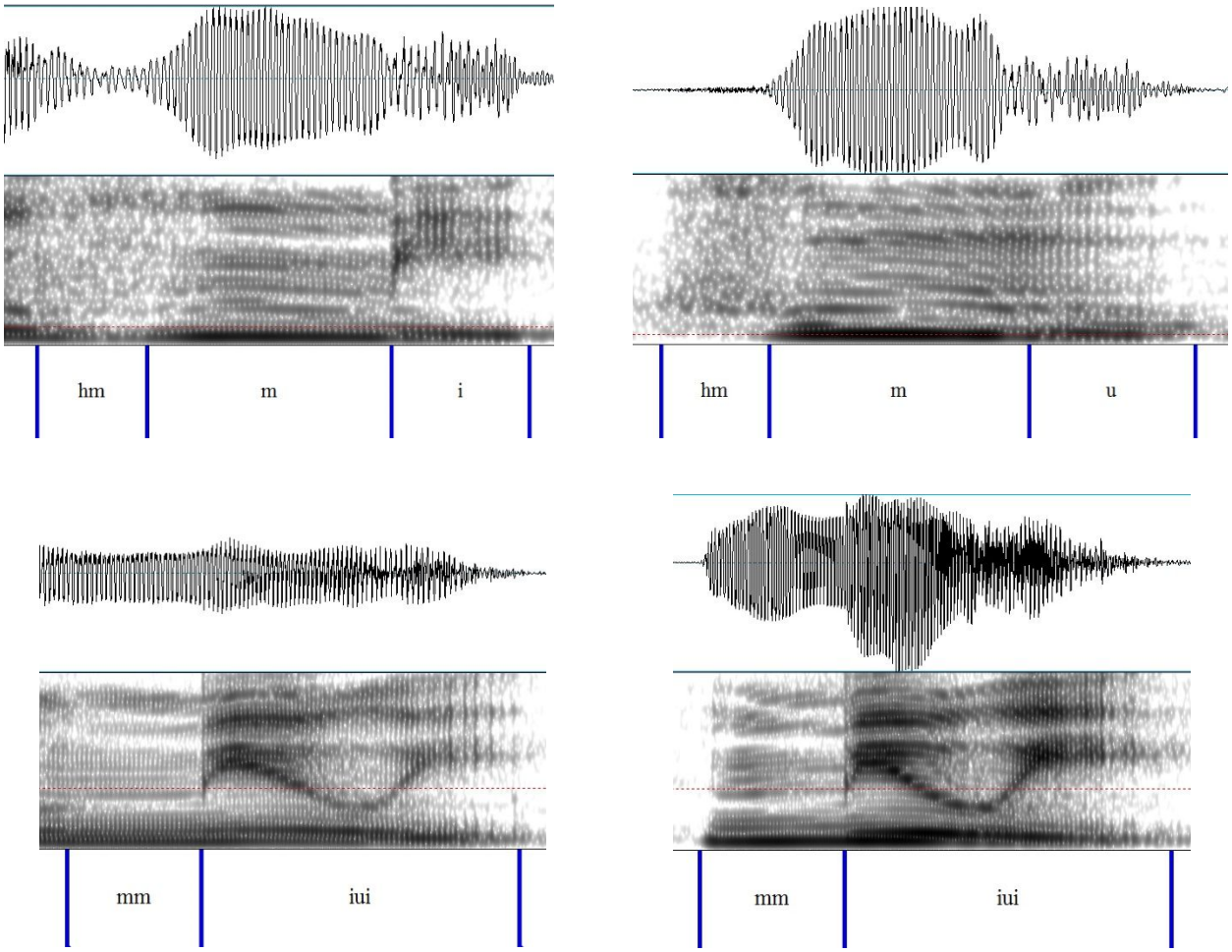

Figure 6: Spectrograms from a single speaker of *hmmi/hmmu* “to wear (shoes)”, *hmmi* as the command form of *hmmu*, and of *mmiui* “ripe” in continuative form. Those on the left are produced within a sentence, those on the right are produced in isolation.

3.2 Results

Statistical analysis revealed there to be a significant difference both within speakers and between speakers for the CPP measure. A t-test between speakers revealed a p-value of < 2.721e-09, showing a significant difference between modal segments and the target sound. Figure 7 shows individual box plots of the 5 speakers, and Figure 8 combines the data of all speakers.

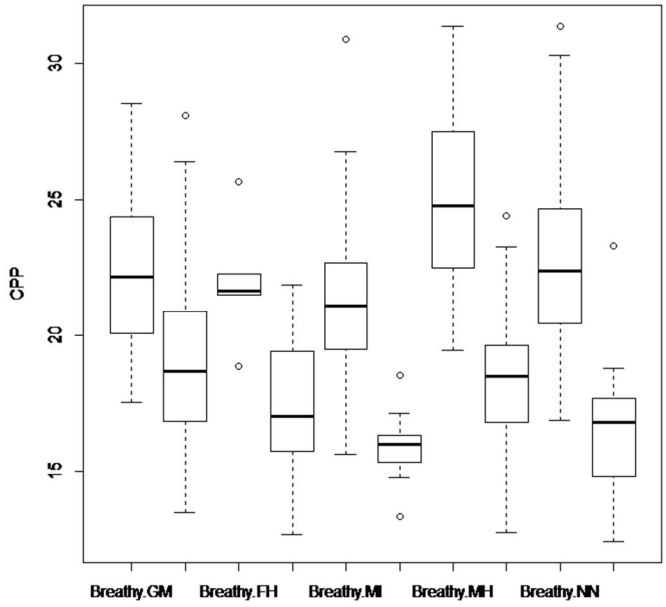

Figure 7: Boxplots of cepstral peak prominence (CPP) data of individual speakers. Unlabeled boxplots show data for modal segments for each speaker. A t-test revealed p-value < 2.2e-16

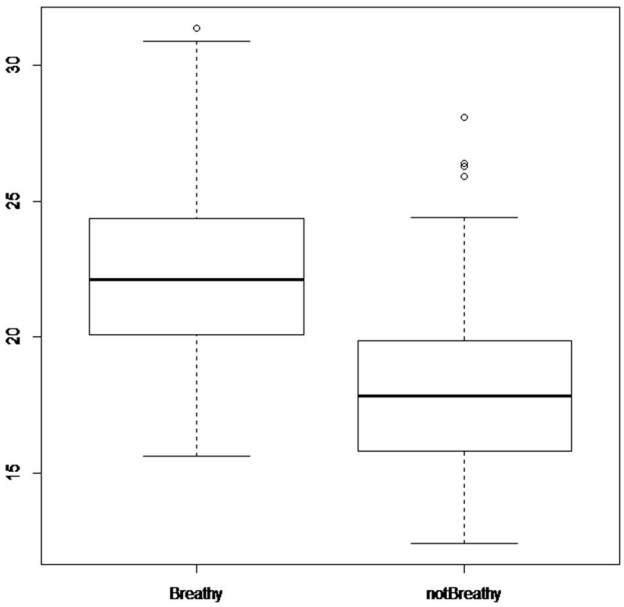

Figure 8: Boxplots of cepstral peak prominence (CPP) data for all speakers. A t-test revealed p-value < 2.721e-09

Looking more generally at the items, a large percentage of them appeared with voicing throughout. For the alveolar sound, 70% of occurrences were voiceless, while 30% were voiced. The bilabial, on the other hand, had far more voiced instances; only 30% voiceless and 70% voiced.

3.3 Discussion

From the analysis it is clear that there is a phonemic difference between nasal voicing states in Ikema. Spectrograms of the target sound show a clear decrease in amplitude and an increase in noise, typical of voicelessness and breathy voicing state (Gordon & Ladefoged 2001). Judging from the durational differences within words, the voiced/modal segment being longer than the voiceless/breathy segment, it is likely that the beginning of the voiced segment is part of the target sound. This segmentation is similar to that in Burmese voiceless nasals to help distinguish place of articulation and make the sound perceivable. This also resembles what has been found with breathy nasals in Sumi, which report a breathy portion and a modal portion.

It should be noted that the voiceless/breathy nasal only occurs as a geminate, with a voiced modal nasal following it. It is more likely these are geminates and not one long phoneme because the length of these voiceless-voiced segments are double the length of modal nasals found in #NC or #NV environments. The voiceless/breathy segment is roughly the same length as modal nasals found in these non-geminate contexts. The voiced segment of the geminate is longer, suggesting that the initial portion of voicing is part of the voiceless/breathy phoneme. This is likely to aid perception as is found with other voiceless and breathy nasals in languages such as Romanian, Burmese and Sumi.

The distribution of voiceless and breathy versions of the target sound suggest that the two forms are in allophonic variation. With the current data it would seem that the voiceless nasal only occurs word-initially, and even then it may be voiced in rapid speech as is seen in some of the sentences provided by speakers. Therefore, the voiceless nasal variant may only occur phrase-initially, although more analysis of discourse is needed in order to confirm this claim. What is certain is that the breathy variant occurs in the word-medial and word-final positions, having no occurrences of the voiceless nasal in these word positions. The percentage of instances of each sound for place of articulation shows the prominence of the breathy variance, although why it is more present for the bilabial as compared to the alveolar is difficult to determine. The most likely explanation is that the bilabial occurs more frequently in the medial and final position than the alveolar, the word list only having a single item with the alveolar nasal in word-final position (and no items with it in the medial position).

Based on the data collected and analyzed, there is a phonemic distinction between voiceless and modal nasals in Ikema. These voiceless nasals have the potential to occur as breathy nasals in the word-medial and word-final positions, and in some cases occur word-initially. At present, the most logical analysis of the breathy nasal is its status as an allophone of the voiceless nasal.

CHAPTER IV: Perception Task

While on the island, a second task was developed to determine whether speakers could differentiate between voiceless nasals and voiced nasals as articulated by a single speaker. This task was also designed to attempt to discover whether speakers perceived differences between word-initial and word-medial voiceless nasals, as the acoustic data suggests they are quite distinct. A task such as this would also provide evidence missing from previous acoustic studies of voiceless nasals, which have primarily focused on production.

4.0 Materials

The stimuli were created based on pre-recorded words of Ikema as articulated by a single speaker. These pre-recorded words were then used to create non-word stimuli using concatenative synthesis. The concatenation was based on diphones, using phonemes from words that would match the formant transitions of the non-words. For example, the stimulus /ɑn̥ɑ/ was created using the /ɑ/ from the word *an* "net", the /n̥/ from *hnna* "rope", and the /ɑ/ from *hnna*. These sounds were combined in Praat using the concatenation feature. Because of the exploratory nature of the task, stimuli were not perfect. Duration and pitch were not altered, leading to choppy synthesis. Ten items were created in total, six of which were developed to compare voiced and voiceless nasals in various word positions. Four others items were created to act as fillers, and did not contain nasals.

4.1 Procedure

Three participants agreed to take part in the perception task. Each participant was asked to wear a set of headphones for the duration of the task. Each trial consisted of 2 stimuli played one after the other. These were repeated for the participant in succession up to three times upon their request. They were presented with 5 pairs of stimuli each, 3 of which compared some type of nasal. The trials with nasals consisted of different pairs for each participant in order to maximize responses to a variety of combinations. The participant was asked to determine whether the stimuli pair of each trial were the same or different. Often on top of this, speakers would elaborate their answers, explaining how they were different or similar to previous stimuli as well. All answers were given orally, the researcher noting the answers on paper.

4.2 Results

The results for the three participants can be found below in Table 2. All three participants did fairly well at perceiving a difference between voiced and voiceless nasals in a variety of contexts, although they seemed unable to label them as voiceless nasals. Participants 1 and 2 gave responses for the voiceless phonemes as having pauses or shorter durations than voiced phonemes, but labelled them as voiced nasals. Interestingly, participant 3 perceived all of the voiceless nasals as an obstruent or obstruent cluster, seeming to focus in on the noise portion more than the other two participants.

Participant	Trial	Stimuli Pair	Same/Different	Comments
1	1	/sa/ vs /ssa/	Different	
1	2	/an̥n̥a/ vs /n̥a/	Different	perceived as voiced nasals
1	3	/ana/ vs /an̥a/	Same	
1	4	/itii/ vs /ittii/	Different	heard /tt/ as /d/
1	5	/na/ vs /n̥n̥a/	Different	perceived as /naa/ and /na/ - said that second /n/ was "half the duration" of the nasal in (2)
2	1	/sa/ vs /ssa/	Different	
2	2	/na/ vs /n̥a/	Different	perceived both as voiced nasals, /nna/ and /na/
2	3	/ana/ vs / an̥n̥a/	Different	pause in second one
2	4	/itii/ vs /ittii/	Different	heard /tt/ as /d/
2	5	/an̥a/ vs / n̥n̥a/	Different	perceived as voiced
3	1	/sa/ vs /ssa/	Different	
3	2	/an̥n̥a/ vs / n̥n̥a/	Different	/aftaa, astaa/ and /ta/
3	3	/na/ vs /n̥a/	Different	/nna/ and /sa/
3	4	/itii/ vs /ittii/	Same	
3	5	/an̥a/ vs / ana/	Different	/aftaa, astaa/ (same as 2) and /anna/

Table 2: Results of perception task for three participants.

4.3 Discussion

Based on the results, it would appear speakers are having difficulty perceiving the voiceless nasals as voiceless. They do, however, recognize there to be some difference between the voiceless and voiced segments as can be seen in Participant 2's second trial. Participant 3 struggled with the task, likely because of how odd the situation was for him, never having participated in an experiment concerning his own language. These speakers have also probably never heard non-words in their language before, which is likely a bit shocking when first experienced. Participant 3 did, however, give some interesting results clearly perceiving the voicelessness of the nasals despite identifying them as fricatives (trials 2 and 5).

The stimuli were not high quality, as this task was planned and created while on the island simply out of curiosity. Thus, the concatenation is not perfect, nor are the created non-words. The non-word stimuli don't all follow the morpho-phonotactic rules of the language, Ikema seeming to require a minimum of 2 mora in an utterance in order to be considered a word. It was also brought to my attention later that /ssa/ is in fact a word (meaning "plant"), which may have created some lexical affects when participants heard this stimuli pair and those following. Therefore, the stimuli themselves may be causing problems.

Currently a future version of this task is being created. This new version will be entirely synthesized, in order to avoid awkward concatenative effects and to allow ample time to perfect the stimuli. The stimuli creation involves parametric synthesis in Praat using the KlattGrid function. Having a synthetic voice may reduce the desire for speakers to hear a real word, as was the issue for participant 3. The synthetic voice may also cause its own problems, because of the unnatural context for participants to hear what is supposed to be Ikema phonemes. Thus the predicted success of this perception task will largely depend on how willing speakers are to participate in such a foreign task. Regardless, the outcome of the task will offer insight into Ikema and the role synthesis may play with under-documented languages.

CHAPTER V: Discussion and Conclusions

The production study described in Chapter 3 provides strong evidence pertaining to the proposed theory that voiceless nasals in Ikema surface as a different sound in specific contexts. After statistical analysis of the CPP measure, it seems clear that these sounds indeed differ from voiced modal nasals despite containing voicing throughout word-medially, word-finally and phrase-medially. The CPP measure served to test the hypothesis that these sounds when appearing with voicing throughout surface as breathy voiced nasals, differing perceptually from voiced modal nasals in the language. While the perception study did little to aid in supporting this hypothesis because of the poorly formed stimuli, the voiced and voiceless stimuli were more often than not perceived as different although speakers were unable to label them correctly. These observations suggest that, given a more intelligent design, a perception task may yield positive results.

As in many projects concerning endangered languages, there are limitations of the research process that are difficult to avoid. Namely, the need to use the dominant language Japanese in elicitation sessions can create difficulties for speakers. Japanese is known to have an influence on the way in which speakers use Miyako, as in a natural discourse setting speakers often mix the two languages. As a foreigner asking for the production of these words, there may be over-articulation affects, as speakers try to pronounce the words as perfectly as they can. There is also a chance they may avoid articulating the voiceless nasal phoneme because they are aware it is difficult for non-native speakers to perceive. In an attempt to avoid this, speakers were asked to produce sentences with the target words spontaneously, hoping that rapid speech would minimize these effects. Another issue is the less than ideal recording settings, sometimes varying from speaker to speaker because of a need to record in each participant's home. Some speakers

are also unaware of the sensitivity of the equipment, often disrupting recordings by using gesture on the table surface where the microphone has been placed. Early on in the research process, it became clear that some speakers are also more skilled at vocabulary recall than others, causing some recording sessions to be more fruitful than others. This variability also made time an issue, only allowing for 6 participants in total to be recorded. Like with any project intimately involving volunteer participants, prior to research participation a trusting relationship must first be formed, something that is crucial for language projects such as this to continue. This factor also contributed to the lengthy time spent outside of collecting data but has helped formulate a positive connection with community members for future research.

The findings of this study contribute to the typological study of nasals cross-linguistically, presenting a unique allophonic variation between breathy and voiceless nasals. At present Miyako Ikema is the only language known to have this variation, although it seems a possibility for Tibeto-Burman languages where either the breathy or voiceless nasal seem to have prevalence. Overall, these results demonstrate that one of the major cues of voiceless nasals is simply increased airflow, a characteristic predominant in breathy voicing state as well.

Future directions for the study include further investigation of perception and how these sounds surface in discourse. As described in Chapter 4, a new version of the perception task is currently being designed, involving entirely synthetic stimuli created through parametric synthesis. Studying the target sound in discourse would give more insight into the nature of the allophonic variation between breathy and voiceless nasals, specifically whether the voiceless nasal surfaces in any context other than in careful speech word-initially.

Based on the evidence gathered, it seems highly likely that the non-modal voiced nasals in Ikema involve allophonic variation between the voiceless nasal and breathy nasal. At present

it seems that the voiceless nasal only appears phrase-initially or in some contexts in the word-initial position, while the breathy nasal occurs in all other contexts. Future research will determine the extent of the relationship between the two sounds and how this may apply to spontaneous speech.

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APPENDIX A

Voiceless nasal	Meaning	Japanese	Minimal Pair	Meaning	Japanese
n̥mii	to draw water put on (shoes) to step on	汲む (kutsu o) haku fumu	**mmii**	to ripen	jukusuru
n̥mu	cloud	kumo	**muu**	seaweed	
n̥na	rope	tsuna	**nna**	snail	sazae
n̥nagii	to attach to	tsunagu	**nnaagyaa**	not yet	madamada
n̥nu	horn yesterday	tsuno kinou	**nnuzu**	type of octopus	iidako
n̥ntaaguutaa	to march	hageshiku fumu	**nnta**	seed	kinomi
n̥ndi	yes	hai, soudesu	**nndi**	yes	hai, soudesu
n̥npajja/n̥nhajja	to step wrong, miss footing	fumihazusu	**nnpa**	it's bad	iya
n̥nbikii	step on (it)	fuminasai	**nbyaii**	livelihood, circumstances	kurashi
ssan̥mii	fall asleep, go numb	shibireru	**sanmin**	do not understand	rikaidekinai
ffun̥mu	storm cloud (black cloud)	kurokumo	**nfumunu**	warm	atatakai
muzIn̥n	process in harvesting wheat of stepping on husks	mugifumi	**yamazun**	form into piles	山積
sshin̥m	step on coral	shiohigari	**basshin**	do not forget	wasurenai