**Narayan (2007) & Liljencrants & Lindblom (1972)**

**Perceptual Contrast**

Week 5 Handout - LAL 6120

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Narayan, C. (2007) - The Acoustic–Perceptual Salience of Nasal Place Contrasts

This paper investigates contrast patterns in language and posits acoustic-perceptual salience, the noticeability of a sound, as the reason why certain phonological contrasts are more common in the world's languages than others. Narayan makes this argument by examining the perception of the typologically frequent [ma]-[na] and the less common [na]-[ŋa] contrast in syllable-onset position.

In the literature, it has been found that nasals can be difficult to perceive. Regardless, certain nasal onset places of articulation are found in nearly every language of the world, despite this difficulty. Previous literature shows that alveolar, dental and bilabial nasals occur in nearly all of the world's languages that have been studied as opposed to velar nasals which occur in less than half of the world's languages. It is worth noting that when velar nasals do occur, they tend to occur in both onset and coda positions or coda position only.

Previous research has shown that the acoustic distance between phonetic categories are correlated with listeners' perceptions of similarity or difference. Dispersion theory suggests that phonological systems tend towards satisfying the dual needs of maximizing the distinctiveness of contrasts for the listener and minimizing articulatory effort for the speaker

In this paper, Narayan argues that there are sound contrasts, specifically /m/-/n/, that are typologically more common than other sound contrasts, specifically /n/-/ŋ/, due to the perceptual salience and perceptual fragility of the respective contrasts. The perceptually fragile contrast is regarded as such due to the sounds' acoustically similar nature which make them less distinct from each other.

This point is illustrated using four experiments. In this study, each successive experiment builds on the previous experiment.

**Experiment 1: acoustic analysis of Filipino stimuli**

This experiment sought to characterize the acoustic similarities between /m/, /n/, and /ŋ/ in Filipino and Thai to provide an understanding of F2 and F3 characteristics of the nasal for further experiments. It also sought to answer if the syllable onset /ŋ/ is used less often than /m/ and /n/ by speakers whose phonology shows an /m/-/n/-/ŋ/ contrast.

Transcribed corpora of the spontaneous speech of 60 Filipino speakers and 24 speakers of Thai were analyzed. In both languages /n/ is the most frequent nasal when followed by the central (/a/) and back (/o/ and /u/) vowels, while /m/ is most frequent before the front vowels (/i/) and (/e/). Across all vowel contexts, the least frequent nasal is /ŋ/.

The frequencies of F2 and F3 are known to cue place of articulation. For all speakers, the [ma]-[na]-[ŋa] distinction is differentiated by F2 and F3 at the NV juncture. The static measurements provide near-perfect classification of [ma] tokens, with most of the errors occurring in classifying [na] tokens as [ŋa]. This shows that [na] tokens overlap more with [ŋa] tokens than with [ma] tokens.

**Experiment 2: cross-language perception of nasal place**

The second experiment investigated if:

1. English-speaking adults, whose phonology does not contrast syllable-onset /n/-/ŋ/, show poor perception of said contrast and a heightened perception of /m/-/n/.
2. Filipino speakers discriminate between nasal places consistently with the acoustic distinctions that were described in Experiment 1?

Real-speech stimuli were selected from tokens recorded by a single native Filipino speaker. Four tokens of each nasal place ([ma], [na], and [ŋa]) were selected based on their showing minimal within-category variation.

English listeners accurately discriminated the [ma]-[na] contrast at an average rate of 98.8% correct and the non-native [na]-[ŋa] contrast at an average of 45.9% correct. The Filipino-speaking listeners on average showed the expected native level of performance, with an average of 98.8% correct on the [ma]-[na] contrast and 90.8% correct on [na]-[ŋa].

**Experiment 3: discrimination in noise**

Experiment 3 was to assess the perceptual salience interpretation of Experiment 2 by making /n/ and /ŋ/ sound more similar using "noise". The same tokens used in Experiment 2 were used here. The experiment consisted of one unaltered condition and two ''noisy'' conditions differing in signal-to-noise ratio.

For both the English and Filipino listening groups, perception of [ma]-[na] remained almost perfect even with the noise, while their perception of [na]-[ŋa] degraded with increasing noisiness in the signal. It appeared that listeners relied on transitional information in categorizing /m/ and /n/ syllables. [na] and [ŋa] are more similar in F2 x F3 space and F3 was masked due its low intensity.

**Experiment 4: acoustic similarity or token frequency?**

The frequency of syllable onset /n/ and relative infrequency of syllable onset /ŋ/ in speech could affect perception as much as the acoustic structure of the nasals themselves and make one more sensitive to /n/ over /ŋ/. Experiment 4 introduce a third contrast, [ma]-[ŋa] and found no evidence that results from Experiments 2 and 3 could be explained by the low frequency of onset /ŋ/ in Filipino.

Even with frequency, listeners' accuracy on the [ma]-[ŋa] contrast is not different from their performance on [ma]-[na]. Acoustic distance is an influence as the perception of [ma]-[ŋa] in noisy conditions is less similar to [na]-[ŋa] than to [ma]-[na]. Listeners discriminated the acoustically distant [ma]-[ŋa] contrast as well as they did the acoustically distant [ma]-[na].

<u>Liljencrants, J., & Lindblom, B. (1972) - Numerical Simulation of Vowel Quality Systems: The Role of Perceptual Contrast</u>

In this paper, Liljencrant and Lindblom present predictions of the phonetic structure of vowel systems using a numerical interpretation of the principle of maximal perceptual contrast - the more different vowels are in their articulation, the less the risk of confusing them. This makes for clear communication in which vowels are both easy to say and easy to hear.

This study is based on the Lindblom and Sundberg 1969, 1971 model. This model provides a procedure for deriving the formants of vowels by considering specific positions of the jaw, the position of the lip muscles, the position of the tongue and the position of the larynx. These specifics are used to calculate the shape of the vocal tract and cross-sectional areas along the tract. This model provides the 'principle of least effort' which offers that it is easier for certain vowels to be pronounced more open/closed which leads to those respective pronunciations across languages. In this model, the vocal tract dimensions are similar to a typical male speaker.

The following are examples of what the Lindblom and Sundberg model produces.

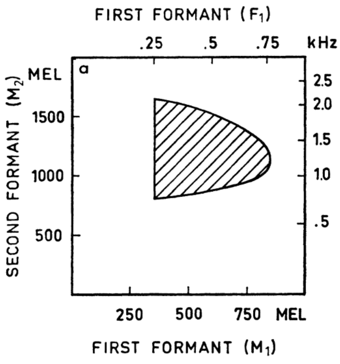


FIGURE 1a

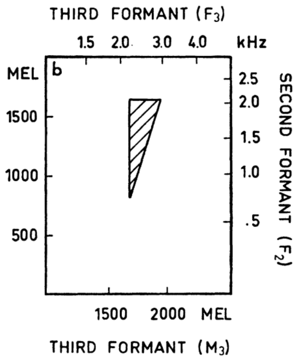


FIGURE 1b

The formula for maximising perceptual contrast $\sum_{1}^{m} 1/r_i^2 \rightarrow \text{minimized}$

The formulas the authors work with are based on physics. Liljencrant and Lindblom compare the basis of their model to physical forces such as gravity and magnetism.

Using this model, formants are obtained and plotted on an axis. Following the given formulas, formant frequencies were generated for vowel systems ranging from three to twelve vowels. This is shown in Figure 2 below.

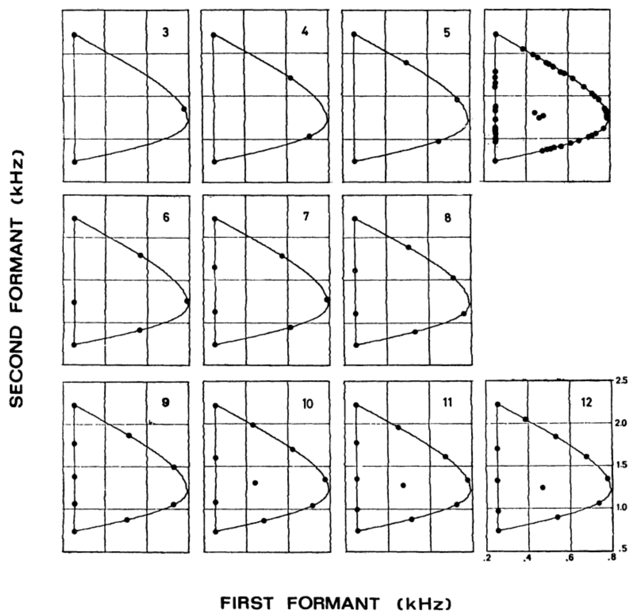


FIGURE 2

When compared with the previous literature regarding other vowel systems, it is shown that the model's predictions most closely align with vowel systems consisting of three, four, five and six vowels each. The model’s predictions are based on formant frequencies in the form of numeric data obtained from broad phonemic transcriptions. With systems that go beyond six vowels, there are inaccuracies with the model’s prediction. However, with each system, there is only one inaccuracy each as seen in Figure 4.

There are some things to note;

- The authors highlight that there are languages such as German and Twi whose entire formant frequencies have not been fully accounted for and compared due to factors such as availability of reliable data and ‘low-level’ phonetic quality differences.
- The data published by the authors cannot be put into use until it has been normalised with respect to features such as size of a speaker’s vocal tract.
- The output of the computer is limited as it is present data that fulfills maximum contrast but there is no guarantee that the degree of contrast is fully maximised or that this is the only possible way to do so.
- This study operates under the assumption that the vowel space is homogeneous
- Boundary conditions (CV structure) play a role in phonology
- The authors hold that little research has been done to explain how language, rather than speech, is structured. With this Liljencrant and Lindblom are referring to the psychological processes behind language.

The authors support Lindbloom and Sundberg’s model and hold that the model generates formant patterns that closely agree with the formants of basic vowel qualities. It is not likely that the model would define a vowel space that is greatly erroneous.

**Discussion Questions**

1. Any criticisms of Liljencrant and Lindblom’s representation?
2. How could Liljencrant and Lindblom’s system account for its errors?
3. What are some possible explanations for why frequency isn't as much of an influence as acoustic distance?
4. In what ways could dispersion theory contribute to phonological change over time?
5. Are there uncommon contrasts in a language you speak?