# Experiment 5: Aerodynamic measures of nasal coarticulation in vowels next to nasal consonants that differ in syllabification

## I. Introduction

It is commonplace to hear that vowels are nasalized next to nasal consonants in English and many other languages. Nasalization of a vowel before a nasal consonant is the result of lowering the soft palate early, in anticipation of its low target position in the following nasal. This is an example of an extremely common phonetic phenomenon, **coarticulation**. Coarticulation is the anticipation (or carryover) of an articulation arising in one speech sound into the interval during which the preceding (or following) sound is pronounced.

In this experiment, we want to see how far ahead a speaker might anticipate the low soft palate position of a nasal consonant and whether certain kinds of segments might interfere with that anticipation.

## II. Methods

### A. Materials

Each experiment group will record 4 speakers (two male, two female) producing the real and nonsense words on the left or right below in the sentence, “Jane/Joan will say/sew ___ right now.” One male and one female speaker will pronounce the words with the vowel [e] on the left, and the other two speakers (one male, one female) will pronounce the words with the vowel [o] on the right:

| | | | |
|---|---|---|---|
| aim | Abe | own | ode |
| haim | | hone | |
| waim | | yone | |
| lame | | loan | |
| same | | sown | |
| tame | | tone | |

plus two more phrases in which the words “say” and “sew” are replaced by “sail” and “soul” and “sake” and “soak” and the following word is “aim” or “om;” that is, the phrases are:

| | |
|---|---|
| sail aim | soul om |
| sake aim | soak om |

Speakers who pronounce the words with [e] on the left will use the name “Jane” and the verb “say” in their frame sentence, while those who pronounced with words with [o] on the right will use the name “Joan” and the verb “sew.”

B. Procedures

Each word should be pronounced six times (we will measure five repetitions). This is a total of 9 * 6 = 54 utterances from each speaker. Each member of each experimental group will measure the data from one speaker, but all the data will be pooled in the final write-up. Each word should be written in large letters in the frame sentence on a separate index card. The speakers read through the index cards, repeating each word in the frame sentence once, then shuffle the cards to change their order, and repeat until six clear repetitions have been recorded. Have your speakers practice reading all the sentences aloud before attaching them to the apparatus or collecting any data. It is important to have them practice, because the sentences do not make sense and yet your speakers need to be able to read them fluently. Listen carefully to how they pronounce each utterance while they practice them and correct them if they don't say them the way you want them to. Also correct them during the recording itself if they don't pronounce each utterance in the intended way.

It would be best to recruit speakers from among your friends outside the class, so they won't know the purpose of the experiment before the data are collected. They should all be native speakers of American English– this means that American English was the language they were exposed to first in their lives and was the principal language spoken to and around them in their childhoods. They should also suffer from no speech or hearing pathology. You'll need about 45 minutes of their time to collect the data.

C. Measurement

We are interested in measuring the level of air flow out of the nose, using the procedures and apparatus in the Phonetics Laboratory which has been demonstrated for you. You will take 7 measurements from each token:

(1) End of the vowel [e] or [o] in the names "Jane" and "Joan," just before the nasal consonant begins. These measurements serve as reference values against which you can compare the other values you measure.

(2) (a) At the beginning of the vowel in the word "say" or "sow,"
(b) In the middle of this vowel,
(c) At the end of this vowel,

(3) (a) At the beginning of the vowel in the next word,
(b) In the middle of this vowel,
(c) At the end of this vowel.

All these locations can be estimated by eye from the displays.

Then, for each token, you will subtract the value measured in the reference word in that token from each of the five measurements made in the test phrase in that utterance. As

that value was recorded immediately before a nasal consonant, it represents a high level of nasal air flow. If another measurement represents lower flow, the difference will be negative, while if it represents more flow, the differences will be positive instead. That is, negative values indicate less nasalization and positive values more.

Once the measurements are made, you will enter them in a spreadsheet such as Excel, and calculate these differences, and then the means and 95% confidence intervals for the differences for each of the eight words. Excel has functions (AVERAGE, STDEV, and CONFIDENCE) that can be used to calculate these values. These will then be used to make the comparisons listed below. You calculate these values in Excel in the following way. To calculate the mean, type:

=average(Xm:Xn)

into an empty cell. "Xm" and "Xn" refer to continuous stretch of a column of values, which are the individual measurements you want to calculate the average of, where "X" is the letter naming the column and "m" and "n" are numbers referring to the first and last row of the stretch of values. To calculate the 95% confidence interval of the mean, you first have to calculate the standard deviation of the mean. The syntax is exactly the same as for the mean calculation, just the name of the function is different. Again, in an empty cell, type:

=stdev(Xm:Xn)

Suppose the cell where you calculated the standard deviation is Xq, then to calculate the 95% confidence interval, you type in yet another empty cell:

=confidence(.05,Xq,n)

where *n* is the number of measurements you're calculating the confidence interval for.

The 95% confidence is the interval within which you may be 95% confident that the mean value occurs. If two means differ in value and their 95% confidence intervals don't overlap, then you can be confident that one mean is outside the 95% confidence interval of the other, and therefore that the difference between the means is statistically significant. If one mean is instead contained with the confidence interval of the other, then you must instead conclude that the two means are statistically different from one another.

Once you have finished these calculations, you can then use them to determine how early your speakers begin to lower their soft palate in anticipation of the upcoming nasal and whether certain intervening segments interfere with this anticipation. The figure below shows hypothetical data for two conditions, one where no consonant intervenes between the two syllables and one where the consonant [s] separates them.

These values show that less air flows out of the nose at all measurment points when [s] intervenes than when it does not. Keep in mind that these are hypothetical data: your results may differ.

Graphing your data in a chart like this will make it very easy to see which differences are likely to be significant. The simplest way to do this is with a pencil and graph paper, although Excel can also be used to make graphs (If you want to see how to make a chart like the one here, see me).

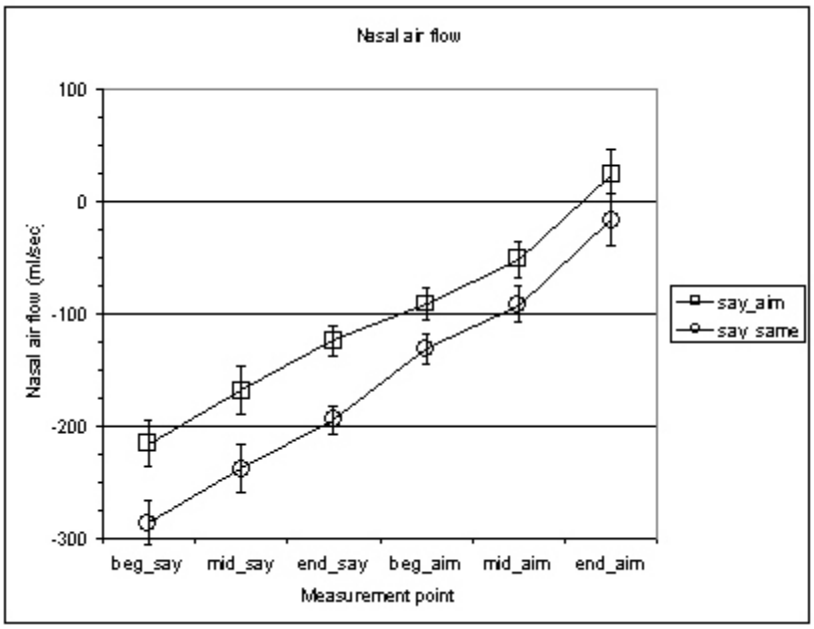


**Figure 1**. Hypothetical data showing the mean differences in nasal air flow at six measure points preceding a nasal consonant between values measured at these points and the reference value for two utterances, “say aim” and “say same”. Error bars show 95% confidence intervals.

The comparisons of interest are listed below. Your write-up of these results should present each one along with answers to the questions.

(1) Compare nasal air flow between corresponding locations – beginning, middle, and end – in the vowels in “say” or “sew” and “aim” or “own.” Does more air flow out of the nose at these locations in the second than the first word? If so, why is that result unsurprising?

(2) Compare nasal air flow between corresponding locations in the phrases, “say aim” and “say Abe” or “sew own” and “sew ode.” How much more nasal air flow is there at each location when the final consonant of the second word ends in a nasal than when it ends in an oral stop?

(3) Compare nasal air flow at each of the six locations between “say aim” or “sew own” and:

(a) “say haim” or “sew home,”
(b) “say haim” or “sew hone”
(c) “say waim” or “sew yone”
(d) “say lame” or “sew loan”
(e) “say same” or “sow sown”
(f) “say tame” or “sew tone”

(g) “sail aim” or “soul om”
(h) “sake aim” or “soak om”

(4) Finally, compare the phrases in (3d) with those (3g) and likewise those in (3f) with those in (3h). The question here is whether the position of the intervening consonant in the word has any effect on the extent and nature of spreading nasalization.

Finally, you want to compare your four speakers with one another. Are there any dramatic differences in the timing and amount of nasal air flow between them?

III. Reporting your results

Your report should begin by tersely laying out your reasons for undertaking the study – see the text above for a review of the issues. You next describe your method for measuring nasal air flow, in sufficient detail that someone else could replicate your procedures exactly using the same equipment. Once the methods are described, you then present your results. Although a table could be used to list the differences between the values you measured in the test word and the value obtained from the reference vowel, it would be far more informative to plot your results. The easiest way to do so is with a pencil and a sheet of graph paper, where you plot adjusted nasal air flow values, or you can use Excel. See the examples above for model plots. You’re welcome to come up with a more perspicuous way of analyzing your data.

Your report should describe the significant differences that you observed, and comment more briefly on the cases that were not different. This description should take up each of the comparisons listed above. You need to use your judgment here. If there is no reason to expect a difference between two cases, then there is no need to talk about the failure to find one.