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ACOUSTICS, AND PERCEPTION OF SPEECH
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Lab 14
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Measuring Speech Movements Using Data from X-ray Microbeam System

References

Westbury, J.R. (1991) *The significance and measurement of head position during speech
production experiments using the x-ray microbeam system*, **J. Acoust. Soc. Am. 89**, 1782-1791.

The measurement of movements of the tongue and of other articulators during speech production is
difficult because the structures are not easily accessible. One method that has been in use over the
last 10-15 years uses narrowly-focussed x-ray beams to track the motion of pellets on the tongue,
lips, and other surfaces. A diagram of the x-ray microbeam system is shown in Fig.1. The method
for tracking the pellet motions is schematized in Fig. 2.

The data from this system are in the form of time-varying x and y coordinates of 8 pellets identified
in Fig. 3. There are 4 pellets on the tongue surface (T1, T2, T3, T4), upper and lower lip pellets
(UL, LL), and two pellets on the mandible (MANm, MANi). The figure shows the coordinate
system used to specify pellet locations. The positions and velocities of these pellets can be
observed at the same time as the waveform and spectrogram of the speech.

Available in the computer directory "microbeam" are pellet and acoustic data for two speakers
(JW16 and JW18 which we call spkr1 and spkr2 in this program). The utterances produced by the
speakers are lists of isolated words and lists of sentences. There are three lists of words and one list
of sentences. These lists are attached, together with the file names. The two speakers are identified
in the files.

Some instructions on how to use the microbeam program are attached.

Suggested measurements

There are many things that can be examined in these data. All groups should do the first four items
on the following list. Other suggestions or questions are listed below these four. These are
optional. You may wish to look at other aspects of the data, as you choose.

1.   Look at the pellet traces for any one of the three sentences (tp 069). Press "hue plot selection" under SPATIAL to examine the complete trajectories. Record the point or points in the sentence at which the anterior jaw pellet is a maximally high position? Can you explain?

2.   Now switch to utterance tp013. For speaker 1, record the x-positions of the pellets T4 and UL, and the larger of the y-positions of T2 and T3 in the middle of each of the vowels in the words **seed, sid, sayed (bayed), said, sad, sod, sawed, sud (dud), sewed, sood (wood), sued, surd**. Explain your results. Plot the results as a function of the vowel (in the order given).

3.   In tp065, compare the x-position of the UL pellet during the /s/ in **this** and the /š/ in **cash**. Explain.

4.   In sentence 3 of tp069, compare the tongue-body position (especially T4) in the middle of the vowels in **coat** and **both**. Comment.

Optional parts:

5.   In tp065, compare the position of the LL pellet during the initial consonant closure in the words **flip** and **blend**. Explain any differences you see.

6.   Compare the x-position of the UL pellet during the /s/ in the words **seed** and **sued** (tp013). Explain any differences you observe.

7.   In tp013, examine the movement of the tongue body as a function of time in the vowels in the words **said**, **seed**, and **sayed**. Comment on the amount and direction of the movements.

8.   Examine the movement of tongue pellets during the production of /r/ sounds in the sentences. Subject 2 is particularly interesting here, but you might also compare with Subject 1.

Instructions for starting up microbeam program

> Login to labc
> type *matlab*
> type *cd ../mbeam*
> type *mavis*
> click on *data*
> click on *subj1* (or *subj2*)
> click on desired utterance set (*tp013, tp065, tp066 or tp069*).
> click on *mavis*, "*about mavis*", to learn more.

Some instructions for using MAVIS

To delineate a portion of an utterance for closer examination, click near left end of upper panel and move cursor to beginning of desired segment. Do the same at right end of upper panel to specify end of desired segment.

You can read off values of x and y coordinates of a pellet on the control panel by locating cursor at selected place on the desired panel.

To see the entire trajectory within an utterance, click on "*hue plot selection*" under SPATIAL.

To remove these trajectories, click on "*reset view*".

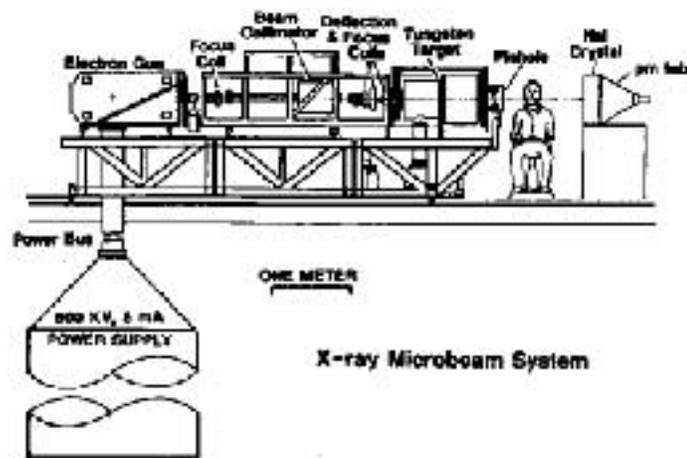To play, click on "*play*" in control panel or "*yack*" in TRAJECTORY menu.

FIG. 1. A cross-sectional view of the x-ray microbeam system (ada from Abbs et al., 1988, and reprinted with permission from the Amer Society of Mechanical Engineers), showing the customary position of speaker within the *system image field*, generally defined as the conishaped *spatial volume* originating at the system pinhole and bounded by plane surface of the NaI crystal detector.
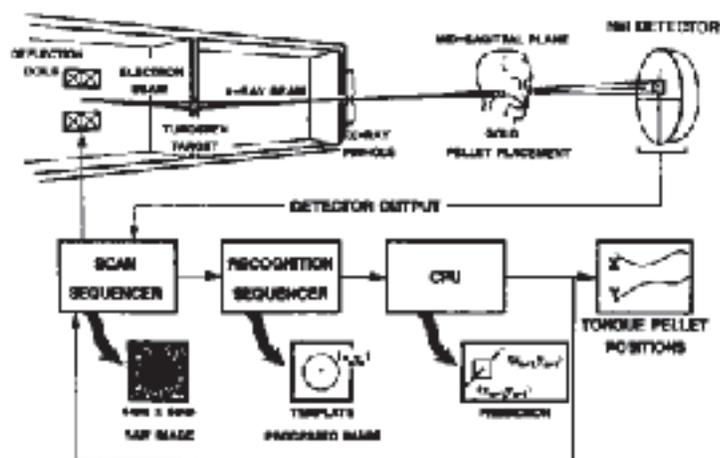
FIG. 3. A schematic representation of the sequence of operations that is required to track pellet motions during speech (adapted from Abbs et al., 1988, and reprinted with permission from the American Society of Mechanical Engineers).

Figure 5.2: Approximate pellet placement locations