

**6.542J, 24.966J, HST.712J LABORATORY ON THE PHYSIOLOGY,
ACOUSTICS, AND PERCEPTION OF SPEECH
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Kenneth N. Stevens

Joseph S. Perkell

Stefanie Shattuck-Hufnagel

Lab 7

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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 `~lab/6.542/mbeam/` are pellet and acoustic data for two speakers (JW16 and JW18 who we call Subject 1 and Subject 2 in this lab). The utterances produced by the speakers are isolated words (three lists) and sentences (one list). 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 look at other aspects of the data, as you choose.

1. Look at the pellet traces for any one of the three sentences (tp069). Press “hue plot selection” clicking on the right mouse to examine the complete trajectories. Record the point or points in the sentence at which the anterior jaw pellet is at a maximally high position. Can you explain?
2. Now switch to utterance tp013. For Subject 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 /ʃ/ 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 using the microbeam program (MVIEW)

- Login to the labc account
- Open an xterm window and then change directory to the 6.542 (type `cd 6.542`)
- Change directory to the mbeam/ sub-directory (type `cd mbeam`)
- Open the matlab application (type `matlab &`)
- In the Matlab window, type (`mview subj*`) to open the MVIEW
(The Variables menu allows you to select which subject tokens you wish to view)
- Clicking on the spectrogram or any of the trajectory plots allows you to see the cursor and also allows you to see microgram pellets' position, in the Trajectory panel, at the point of cursor. Look at the menu functions to determine the CTRL-KEY short cuts.
- To play the sound file, go to the MVIEW menu, then to Play (to play selection --> CTRL-P)
- To delineate a portion of an utterance for closer examination, click near left end of upper waveform panel and move cursor to beginning of desired segment. Do the same at right end of upper waveform panel to specify end of desired segment, then press CTRL-U to update the displayed selection.
- From the Control panel at bottom left, to read off values of spectrogram, spectrum, audio or pellet trajectory information (i.e. x- and y-coordinates of a pellet) --> click and hold down the cursor using the left mouse at the selected place on the desired panel.
- If you right click on a panel, special options are displayed. Double-click on the panels to reset.

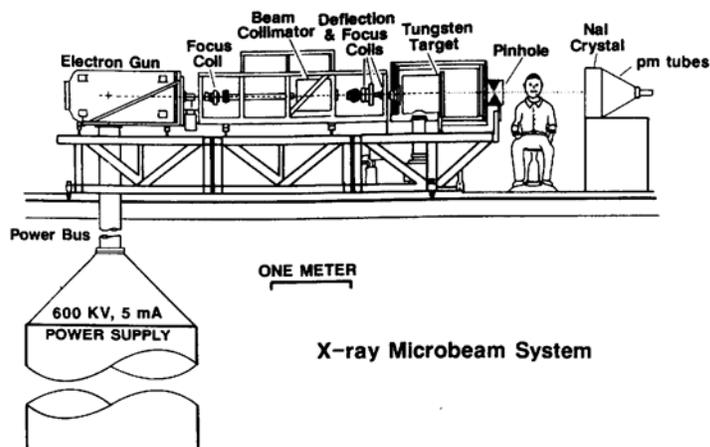


FIG. 1. A cross-sectional view of the x-ray microbeam system (adapted from Abbs *et al.*, 1988, and reprinted with permission from the American Society of Mechanical Engineers), showing the customary position of the speaker within the *system image field*, generally defined as the conically shaped spatial volume originating at the system pinhole and bounded by the plane surface of the NaI crystal detector.

Figure 1

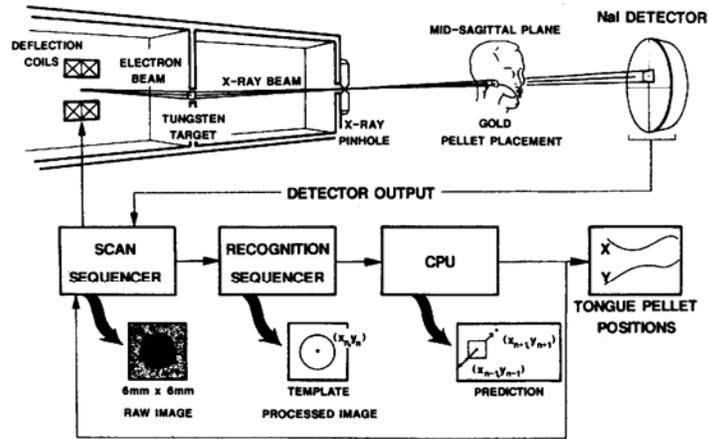


FIG. 3. A schematic representation of the sequence of operations that is required to track pellet motions during speech (adapted from Abbs *et al.*, 1988, and reprinted with permission from the American Society of Mechanical Engineers).

Figure 2

Figure 5.2: Approximate pellet placement locations

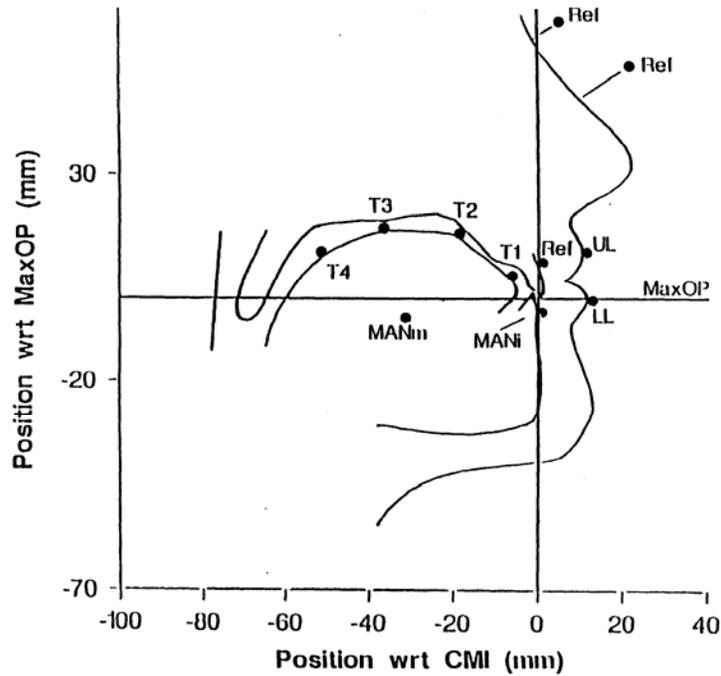


Figure 3*Lists of utterances:*tp013 -- Citation sVd's

side	sawed	*sud (dud)
sewed	sid	*soid (Lloyd)
seed	sad	*sowd (loud)
sod	surd	*sood (wood)
sued	said	*sayed (bayed)

tp066 – Citation words

shoot
country
both
shoot
cash
program
second

tp065 -- Citation words

coat
began
cash
blend
this
pushed
flip

tp069 – Sentences

1. Things in a row provide a sense of order
2. I'll make sense of the problem in a moment.
3. The coat has a blend of both light and dark fibers.