

**6.542J, 24.966J, HST.712J LABORATORY ON THE PHYSIOLOGY,
ACOUSTICS, AND PERCEPTION OF SPEECH
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Part I: Normal Speech Production by Children

References

Imbrie, A.K. (2003), *Acoustical study of the development of stop consonants in children*. In **Proc. 15th International Conference of Phonetic Sciences (ICPhS)**, pp. 1943-1946, Barcelona, Aug. 3-9, 2003.

Goodell, E.W., and M. Studdert-Kennedy (1993), *Acoustic evidence for the development of gestural coordination in the speech of 2-year-olds: A longitudinal study*. **J. Speech and Hearing Research** **36**, 707-727.

In this laboratory we will examine the speech of some children in the age range 2-5 years. This laboratory has two goals:

- (1) Since children have a higher fundamental frequency and higher formant frequencies than adult speakers, the analysis methods normally used for adults needs to be revised. Children also often show greater variability in their speech patterns, and interpretation of the acoustic patterns in terms of articulation is less straightforward. We will experiment with analysis methods appropriate for these children.
- (2) In this age range, children are still acquiring the motor control and coordination that are required to produce the consonants and vowels needed to generate words and word sequences. Some children have not yet acquired some of the basic phonological distinctions in the language. (For example they may not be aware that **bat** and **pat** are different words.) In this laboratory you will examine the children's sound patterns for a number of words and determine how they differ from adult sound patterns. Some examples of utterances produced by a child at two or more times separated by several months are also available for analysis. It will be possible to observe changes in the utterances over time, and interpret these changes in terms of refinements in production.

Stored on the computer are a number of utterances of words and phrases produced by several children. Included are two examples of the same utterances produced by a child at two different times about 6 months apart over an age range from 3 to 4 years. Some of the same or similar utterances produced by an adult female speaker are also available for analysis.

All of the children's and adult's utterances are stored in a subdirectory under *lab6.542*, entitled children. The utterances of the adult female have the prefix **ni**. The children are **jo**, **ha**, and **ae**.

A. First examine one or more utterances of **gus**. There are several utterances of this word produced by three different children and by the adult female.

(i) Measure the maximum and minimum fundamental frequency in each utterance.

(ii) Make spectrograms of at least one child's utterance of the word, as well as that of the adult female. Note any differences between the adult and the child (e.g., time from /g/ burst to vowel onset, amplitude of burst, amplitude and spectrum of /s/. Some of this may require looking at the spectrum at different times.

(iii) Measure the first three formant frequencies in the middle of the vowel in **gus**. To do this, it is probably best to use an analysis window of 3 milliseconds and to do some averaging. The averaging could be done over 50-100 milliseconds in the vowel, or over 20 milliseconds. Or you can use a single 3-ms window strategically placed on one pitch period of the signal. Some adjustment of the position of the window may be needed to get the best display of the formant peaks in the spectrum. From F3, make a rough estimate of the vocal-tract length for the child and the adult. Note that

$$F3 \cong \frac{5c}{4\ell},$$

where ℓ = vocal tract length, c = velocity of sound (35400 cm/s).

B. Stored in the directory children are one child's (jo) utterances of the words **cat**, **dock**, **goose**, and **bee**, representing four extreme vowels. Measure F1, F2, and F3 for the vowels at appropriate locations in the words. Do the same for the female speaker. In a graph of F2 versus F1, plot the points for each vowel. Note the difference between child and adult. Are the values of F3 roughly the same for each vowel? Are the differences between child and adult consistent with estimates of vocal-tract length based on F3?

C. Examination of some consonants. Select at least two consonants for further studies. Examples are /d/, /g/, /k/, /m/. Based on spectrograms and spectra, comment on differences between the child's and the adult's production of these consonants.

D. For one child in the directory (jo), there is a waveform of the word **gus** produced on two occasions six months apart. Make spectrograms of these two utterances, and comment on changes that may have occurred in the child's production over this six-month period.

Part II: Speech Disorders in Children

References

Daniloff, R.G., K. Wilcox, and M.I. Stephens (1980), *An acoustic-articulatory description of children's defective /s/ productions*. **J. Communication Disorders** **13**, 347-363.

Monsen, R.B. (1976), *Normal and reduced phonological space: The production of English vowels by deaf adolescents*. **J. Phonetics** **4**, 189-198.

Minifie, F.D. (ed.) (1994), **Introduction to Communication Sciences and Disorders**, San Diego: Singular.

Ohde, R.N. and D.J. Sharf (1992), **Phonetic Analysis of Normal and Abnormal Speech**, New York: Macmillan.

Disorders of speech production can arise from a number of causes. They can be a consequence of deviant anatomical structures, they can arise from lack of sensitivity to or awareness of particular phonetic contrasts, they can be a result of neurogenic disorders that make it difficult to control and to sequence sounds, syllables and words, and they can be caused by failure to acquire the motor skills needed to produce particular speech sounds or speech sound sequences. Some of these disorders occur because of improper adjustment of articulatory structures that play a role in the production of almost all speech sounds, including the supralaryngeal structures, the larynx, and the respiratory system. Examples are inappropriate adjustment or configuration of the glottis, a velopharyngeal opening that is maintained throughout an utterance, or inappropriate control of respiration. Other problems are associated with the production of individual sounds, either because of the lack of ability to shape the articulatory structures, or because the speaker is unaware of or is insensitive to a particular phonetic contrast. For example, a speaker may be unable to make the sound /l/, or may be unaware of the distinction between the words **meet** and **mitt**. Still other problems are associated with neurological control of the articulatory structures. Thus, a speaker may be unable to plan the sequencing of movements for an utterance longer than a single syllable, or may have difficulty coordinating the movements of the lips and the velopharyngeal opening in a word like **dim**.

In this laboratory we will examine some utterances produced by adults and by children with several types of speech disorders. By looking at the acoustic properties of disordered speech, we will try to make inferences about the articulatory configurations and movements that give rise to the speech.

Stored in ~lab6/6.542/ subdirectories of the Unix workstations are several examples of disordered speech. These are identified in the following descriptions.

Do **ONE** of the following two sections E and F.

E. Misarticulation by children.

In ~lab/6.542/misart/ there are several utterances produced by normal children and by children who misarticulate several sounds.

Included are four versions of the word **sap** produced by children. These are intended to illustrate some kinds of misarticulations of the sound /s/ that occur for some children. One of the words (*sapn8A1*) is normally produced. Three others (*sproap8A1*, *slap8A1*, *sdap8A1*) have been described by speech pathologists as “protruded”, “lateralized”, and “dentalized”, respectively. From spectrograms and from other kinds of acoustic analysis you may choose to do, describe the acoustic attributes of the /s/ for each of these utterances, and suggest how the deviant articulations might give rise to the observed acoustic attributes.

In the same directory there are three versions of the word **dairy** (*dairy1a*, *dairy1b*, *dairy3b*) and two versions of **parade** (*parade1a*, *parade1b*). Two of these words are normally articulated by children and the other three have some misarticulation. Listen to the words and make spectrograms (or other acoustic analyses). Describe the misarticulation and explain in terms of the acoustic data why the words sound the way they do.

F. Speech of deaf children.

In the subdirectory ~lab/6.542/deaf/ there are five utterances. Four of these are the utterance “the paper”, three produced by deaf children and one produced by a normal-hearing adult speaker. The fifth utterance is the sentence “She keeps it in a tank”, produced by a deaf child.

Listen, make spectrograms, and, if necessary, do further acoustic analysis of the utterances of “the paper”. Describe any deviations from normalcy of the utterances produced by the deaf children. Possible differences might include incorrect articulation of vowels or consonants, inappropriate timing, deviant glottal configuration (such as breathiness), etc.

Listen to and analyze the utterance “She keeps it in a tank”. Describe any deviations from normal in the sound, and comment on the articulation that gives rise to these deviations.