

Measuring Duration with Speech Analyzer

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Many languages of the world have phonemic length in either vowels or consonants or both. In this article, I show how to use [Speech Analyzer](#) to physically measure length, give tips for the types of recordings needed for this, and just as importantly, how to interpret your measurements.

Introduction: Why measure duration?

One of the challenges in working on a new language is to find out whether there is a phonemic length contrast, and if so, then which words show it. When we talk about a phonemic contrast, we speak of the *length* of a consonant or vowel. “Length” is a phonological term. But when we are measuring how many milliseconds some sound takes, this physical measurement is more properly called *duration*. If the durations of two vowels are different, there may be a phonemic difference in length, or there may not be. It depends on *how* different the durations are, and if you’ve taken enough of the right kinds of measurements to draw reliable conclusions.

Finding out whether you have a phonemic length contrast is of course crucial in developing a good orthography. If there is a contrast that is ignored in the orthography, there will often be ambiguity in which word is intended, and reading problems are certain. It is possible to determine this just by ear, but if you are having some difficulty or want to quantify the difference between long and short sounds, then this is for you.

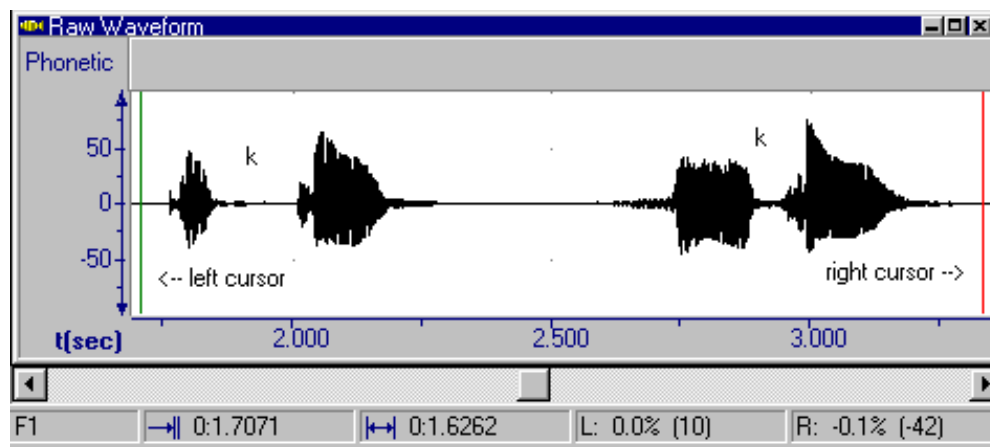
In this article, I discuss

- how to measure duration in Speech Analyzer (SA)
- how to get recordings that will be reliable to use in measuring
- what you need to consider before you can conclude that length is phonemic, and
- finally, I supply an exercise in measuring vowel length from the sound file attached to the pdf.

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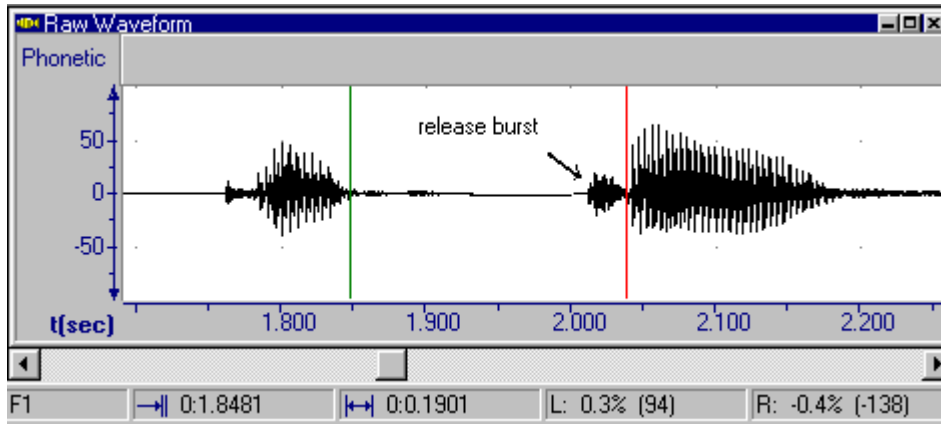
Measuring duration

This article assumes a little familiarity with Speech Analyzer. Specifically, you need to know how to place both the left and right cursor where you want them, and to use the scrollbar zoom on the right side of the display. Look at the waveform display (1). This displays two different words: “the village” and “the catfish” in Kɔnni, a Gur language of northern Ghana. In the middle of each word is a [k] sound. It appears that the [k] is longer in the first word than the second; let’s see what the actual durations are.



(1) SA waveform of two Kɔnni words with medial [k]: tɪkka, gbɪkka

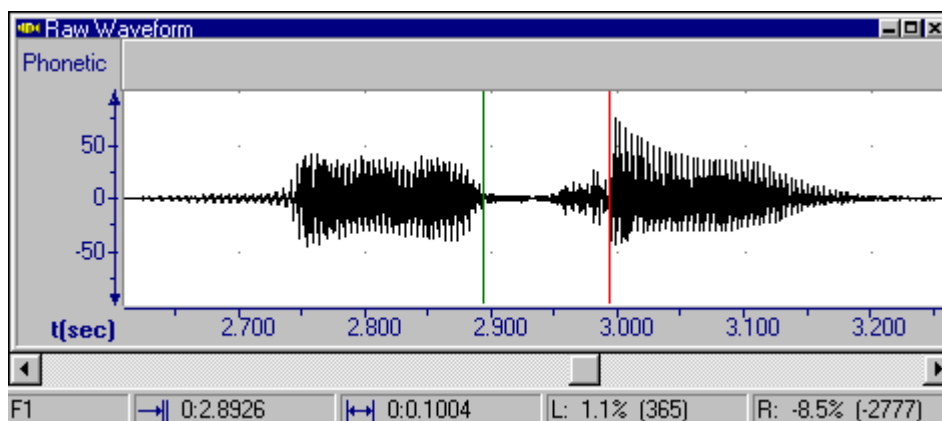
The second number at the bottom of the screen above gives the duration between cursors, in seconds. So between the cursors in the screen above, the duration is 1.6262 seconds. To get a good measurement of the [k] in the first word, we place the cursors around the first word and zoom in, using the scrollbar zoom at the right of the graph (not shown). We then place the first cursor at the place where the stop [k] begins and place the second where it ends, as in the window graph in (2). Note that the [k] has a release burst before the vowel, and I’ve chosen to include this release burst as part of the duration of [k]. (Aspiration looks similar, but is generally longer.)



(2) SA waveform of first Kɔnni word with medial [k]

We read the duration of [k] as 0.1901 seconds. You need to be aware of two things when noting duration measurements: the precision of the reading and the placement of the cursors. Most of the time, durations of segments are reported in *milliseconds*, so we would actually record 190.1 ms but this is too precise. There is some uncertainty on *exactly* where you place the cursors to measure, and a more honest reporting of the number would be 190 ms.

The second word in (1) is zoomed in on in the screen graph in (3), with the cursors again placed around the [k], including the release burst. We see below that the duration of the [k] is 0.1004 seconds, or 100 ms.



(3) SA waveform of second Kɔnni word with medial [k]

When we compare the duration of the first [k] at 190 ms with the second one at 100 ms, it is obvious that this is a significant difference, with a ratio of 1.9:1 between long and short. So we might conclude that

this is a case of a “long [k]” and a “short [k],” and we would be right in this case. There is support from the morphology of *Kōnni* here. It turns out that both words have a suffix [-ka]. The first *stem* of the first word also ends in [k], but the second word’s stem ends in a vowel. Morphologically, there are “two [k]s” in the first word but only one in the second. Furthermore, the circumstances of recording were favorable for comparing these; recording circumstances are an issue that deserves more discussion.

Recording for duration measurements

When you are measuring duration and comparing one word to another, you do not want to use a dramatic story! An effective storyteller will speed up his speech and slow it down for dramatic effect, making consistent measurements impossible. If you have recording conditions that stay pretty constant, it is possible to use recordings made at different times to compare durations. (The VILLAGE-FISH.WAV file was made by pasting one file into another, something easy to do in SA.) In any scientific measurement, the goal is to measure under consistent circumstances. The following are some factors to consider in achieving this consistency.

- Since different people often have different speech rates, compare one person with himself, not with other speakers.
- Make sure the person is speaking at approximately the same rate for all your measurements. For individual words, just saying them one after another in a list is generally fine.
- The number of syllables in a word can also affect phonetic vowel length. Vowels tend to be longer in one- and two-syllable words and shorter in longer polysyllabic words. Compare words with the same number of syllables.
- Compare segments that occur in similar positions in the word, e.g., the vowel in first syllable of one word with the vowel in first syllable of another word.
- Stress can affect segment duration, so don't compare a segment in a stressed syllable with a segment in an unstressed syllable.
- High vowels are inherently shorter than lower vowels. Compare only the same vowel between words.
- Be consistent in where you place your cursor to measure, and report this in the description (e.g., “the beginning of the vowel was measured at the first glottal pulse, excluding the release burst of the preceding stop”).
- It’s easier to measure vowels between stops (plosives) than anywhere else. Before [ŋ], the boundary is often blurry; forget about a clear boundary between approximants and vowels!
- Finally and crucially, a single recording is *not* a sufficient basis for drawing conclusions. You need several recordings of the same word, and then calculate the average of the measurements. Three recordings of the same word is a minimum; ten is great.

Interpretation: Phonemic or not?

Let's say that you have made your measurements and one set of vowels is consistently 1.3 times the duration of the other one. Can you say this is a phonemic difference? Here is what some researchers have found out about the relative lengths of short versus long consonants and vowels.

For consonants, Ladefoged and Maddieson (1996) tell us that in languages with a phonemic contrast in length, long stops have duration between 1½ and 3 times the duration of short stops in careful speech. They don't report on other types of consonants such as nasals and fricatives. In the *Kõnni* example discussed above, where the long [k] was 190 ms, and the short one was 100, the ratio is 1.9:1. This is well within the boundaries Ladefoged and Maddieson report. Even without the morphological information about suffixes and roots, we are probably safe in concluding that there is a contrast in consonant length in *Kõnni*.

Vowels have a bit more complexity. Hubbard (1998) reports on two types of "long vowel" systems. In one system, the *quality* of a long vowel changes as well as its duration. In this case there are two cues to tell the long from the short vowel: quantity and quality. In this type of system, Hubbard found that the ratio of long to short vowels was about 1.5:1. In the other type of system, in a long vowel there is no significant change in vowel quality; the long vowel is just plain longer. In this type of system, the ratio of long to short vowels is about 2.0:1.

Also, Ladefoged and Maddieson (1996) report on an additional complexity. They only know of one language (*Mixe*) that has a 3-way lexical contrast in vowel length. (If you find another, write it up; it is news!) However, some languages can put morphemes together, or historically a consonant has dropped out, with the result that you can have differing vowel lengths of 3, 4, or more vowels. But each additional length constitutes a different syllable.

So then, what of our hypothetical example where we found a duration ratio of 1.3:1 for vowels? This may be too small a difference to be phonemic, yet a systematic difference does exist. If there is such a difference, even though small, then it is time to look for other factors. For example, a vowel before a voiced stop generally has a longer duration than a vowel before a voiceless stop. If you say "pad" and "pat," as in the exercise in the appendix, the [æ] in "pad" will likely be a bit longer than the [æ] in "pat."

As I mentioned before, many people will be able to hear the difference between long and short vowels and consonants. But if there is a problem of any sort in deciding, or if you want to quantify exactly "how long is long," then using Speech Analyzer can be really helpful. For further information, I highly recommend Joan Baart's excellent introduction to acoustic phonetics on the *LinguaLinks Library CD-ROM* (also in the Help files of Speech Analyzer).

References

- Baart, Joan. 1999. *Acoustic Phonetics*. In LinguaLinks Library in Linguistics, under “Phonology” (http://www.ethnologue.com/LL_docs/show_contents.asp?bookshelf=Linguistics).
- Hubbard, Kathleen. 1998. Quantity or quality? Characteristics & Typology of Vowel Length. Paper presented at an LSA meeting, New York City.
- Ladefoged, Peter, and Ian Maddieson. 1996. *The Sounds of the World's Languages*. Cambridge, Mass.: Blackwell Publishers.

Appendix: Practice in Measuring Vowel Duration

A. English vowel duration, from your own recording

1. *English vowel duration*: Record yourself in Speech Analyzer saying the English words “pat” and “pad” five times total each in the frame “Say ___ now” as follows. Do all these in one recording, as follows:
 - Two times say: “Say ‘pat’ now!”
 - Five times say: “Say ‘pad’ now!”
 - Three times say: “Say ‘pat’ now!” (= 10 total sentences in the same recording. The mixing is to try to cancel out any possible list effects.)
2. Save your recorded sound file. Now measure the duration of your [æ] vowels in “pat” and “pad.” Use the scrollbar zoom to make each sentence in turn fill the screen. Measure [æ] in the first sentence and record its duration. Use the horizontal scroll bar (bottom of screen) to scroll the whole recording so you view the next sentence, and again measure its [æ] duration. Measure and record the duration of [æ] for each sentence. Calculate the averages and the ratio of the [æ] in “pad” to the [æ] in “pat,” as below.

Duration of [æ] in frame “Say ___ now”:

	1	2	3	4	5	Average
“pat”						
“pad”						

What is the ratio of the average [æ] in “pad” to [æ] in “pat”? _____

It has been claimed that English vowels are phonetically longer before voiced stops than before voiceless ones. Do your findings support this claim?

B. Kɔnni vowel duration, from VILLAGE-FISH.WAV file

1. *Kɔnni vowel duration*: Open the file [VILLAGE-FISH.WAV](#). Measure the length of the first vowel /ɪ/ in all three tokens of both words, and record them. (The first vowel in both words is phonemically /ɪ/, though phonetically it varies.)

Duration of [ɪ] in two Kɔnni words:

	1	2	3	Average
Word 1				
Word 2				

Ratio of [ɪ] in Word 2 to [ɪ] in Word 1 _____

- How does the long/short ratio in these Kɔnni words compare with the ratio in the English ones?
 - Is the environmental which conditions vowel length in English present in Kɔnni?
 - Would you think vowel length in Kɔnni is phonemic? (At least, based on this very limited data!)
2. *Bonus*: in the Kɔnni words *ɣmaandʊka* and *kɔkka* (both are types of trees) the ratio of the “long” *ʊ* to the short one is only about 1.4 to 1. This should be less than the ratio you got for Kɔnni long to short vowels.) What is a possible explanation for the “shorter” long vowel here? (See [Recording for duration measurements.](#)) ■