Intraoral Air Pressure in Speech

This demo shows some typical intraoral air-pressure curves for selected consonant sounds.

The basic idea is that if we understand what influences the shape of the curves then we have understood quite a lot about the articulations necessary to produce these sounds.

Each air-pressure trace is plotted in parallel with a wide-band sonagram.

(In this version, there is a certain amount of echo in the audio signal, so the sonagram does not show the start of consonant closures as abruptly as it might. This will be upgraded soon.)

Click on the title-bar of each figure to hear the utterance.

1. Voiceless aspirated plosive

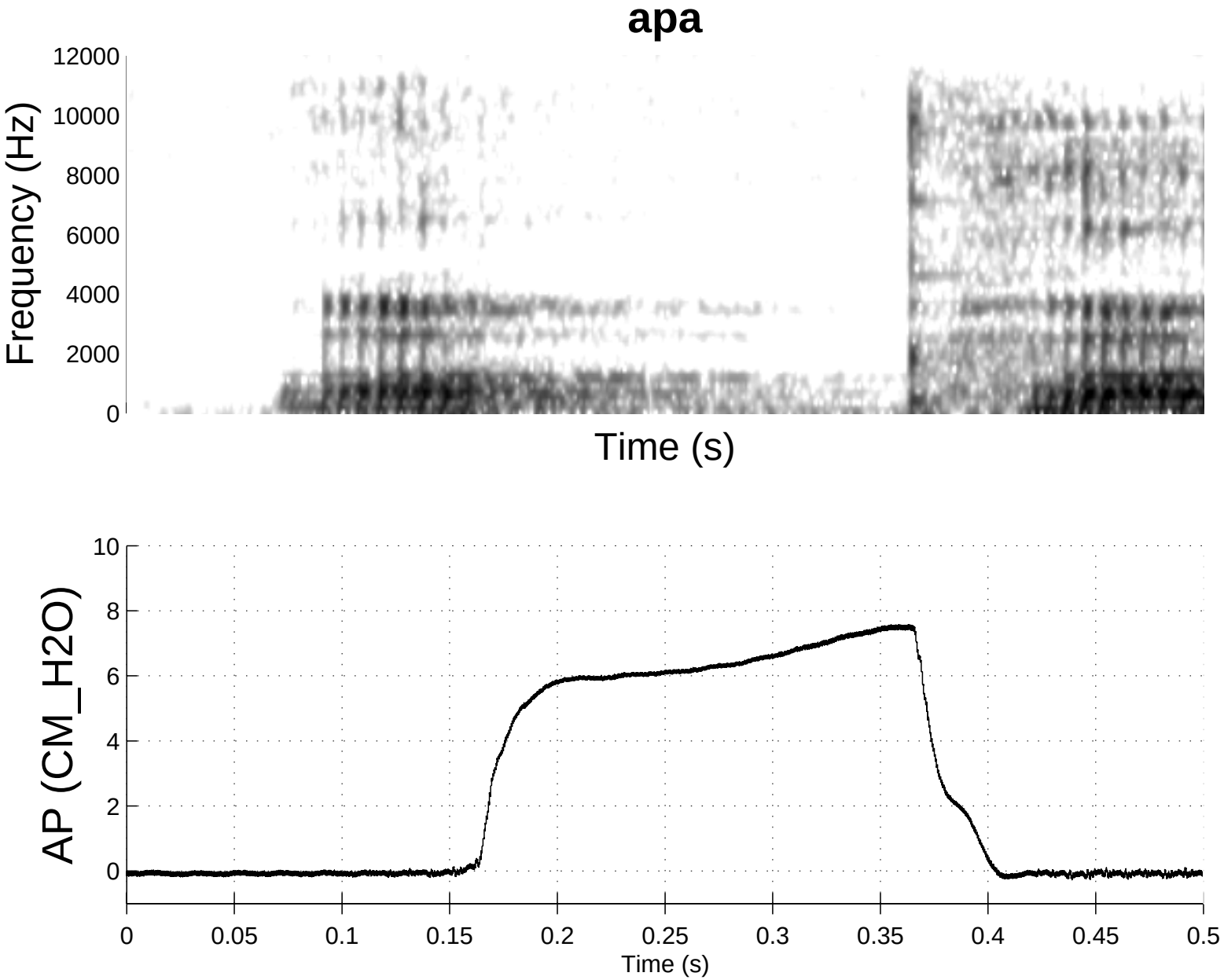
The closure of the lips for /p/ is indicated by a sharp rise in the air-pressure.

At the opening of the lips (marked by the burst in the sonagram) the air-pressure drops again, and voicing for the following vowel starts roughly when the pressure has dropped to zero.

Between the sharp rise and the fall the air-pressure trace is fairly flat, i.e it forms a kind of plateau. If a plateau like this occurs (especially in a voiceless aspirated plosive where we know the glottis is open) then we can assume that intraoral air pressure roughly corresponds to subglottal pressure.

Subglottal pressure is quite difficult to measure directly. Methods include:

- Passing a pressure sensor in a catheter through the nose and then between the vocal folds into the trachea;
- Using a needle to insert a pressure sensor into the trachea through the neck;
- Passing a balloon catheter through the nose and mouth into the oesophagus (since there is a flexible membrane between trachea and oesophagus, pressure variations in the trachea are transmitted to the balloon).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Frequency (Hz)
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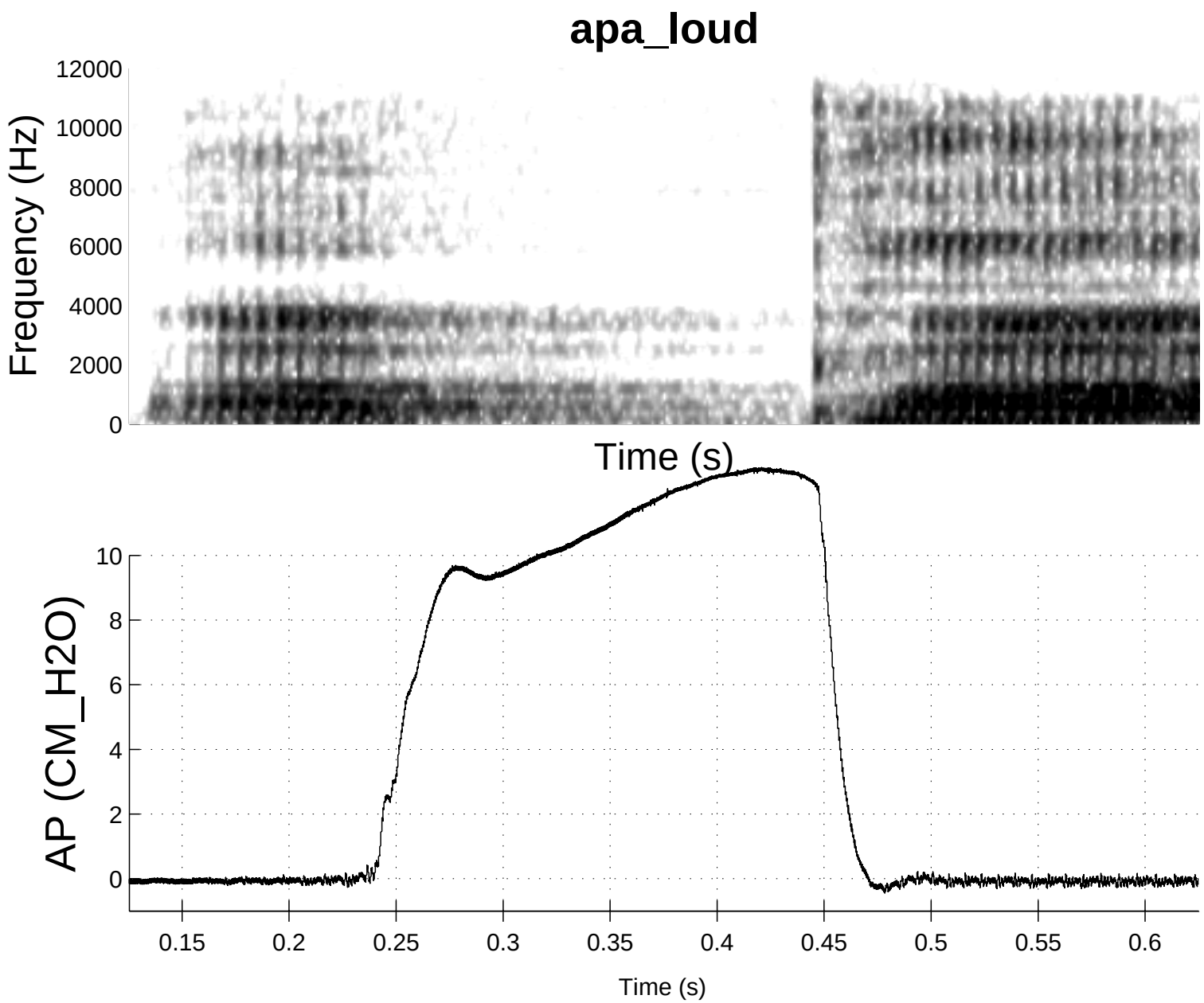
Time (s)

2. Voiceless aspirated plosive (loud)

A louder version of the previous utterance.

Peak oral air-pressure is higher.

We assume that this reflects the difference in subglottal pressure between the two utterances.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Time (s)

3. Voiced plosive

The air-pressure reaches about the same peak value as the /p/ in example 1.

However, the pressure rises much more slowly at the start of the consonant.

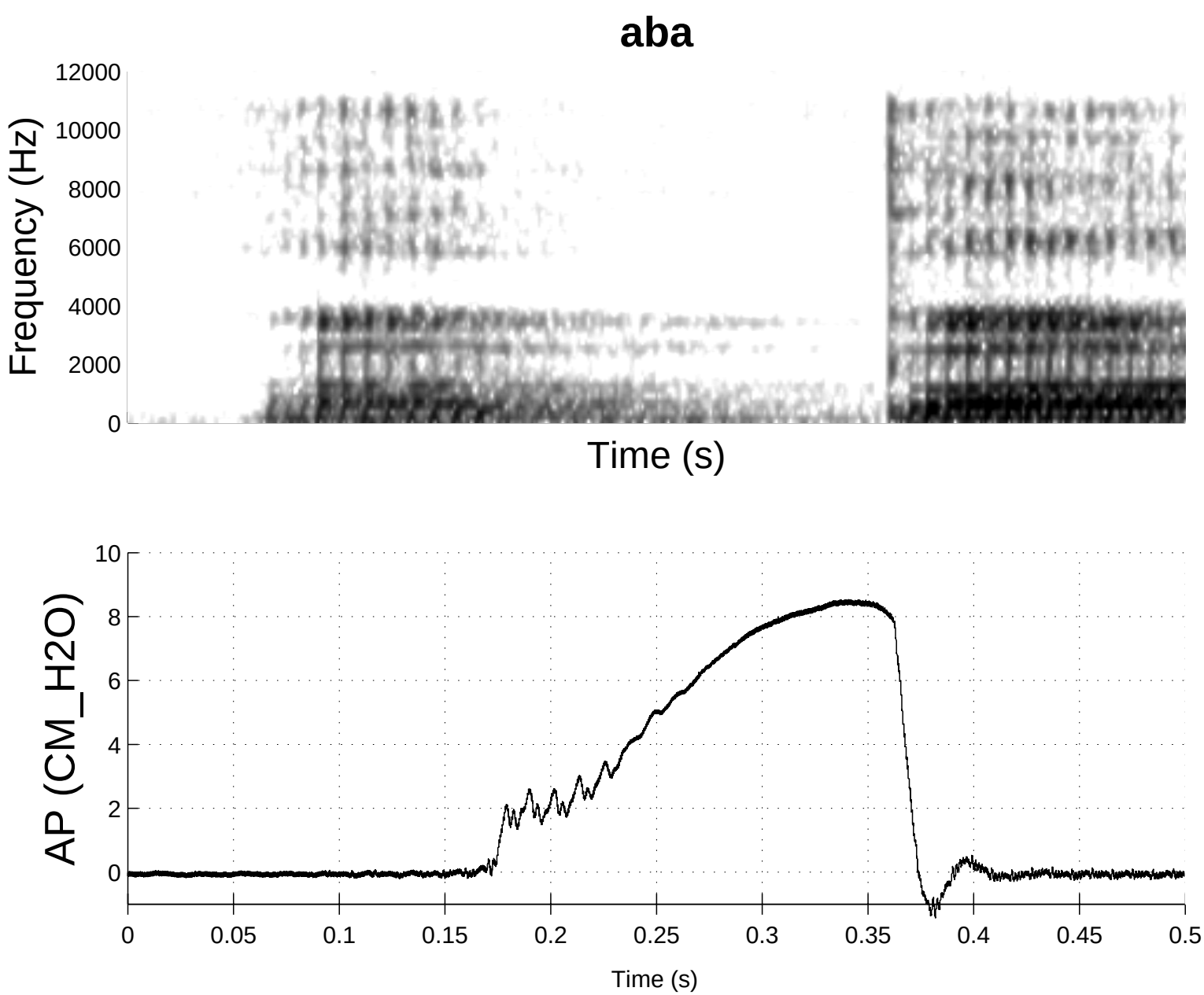
The faster rise for /p/ can be attributed to the abduction of the vocal folds, reducing the resistance to the airflow at the glottis.

For /b/ the vocal folds remain adducted for phonation.

But note how voicing tends to die out as the pressure rises:

There are oscillations in the airpressure waveform related to vocal fold vibration, but they disappear by about 0.25s on the time axis (where the air-pressure has risen to about 5cmH2O).

This is actually not a fully-voiced plosive (quite typical for English or German) and illustrates the important point that voicing cannot be maintained if intraoral air-pressure rises too much.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Time (s)

4. Voiceless fricative

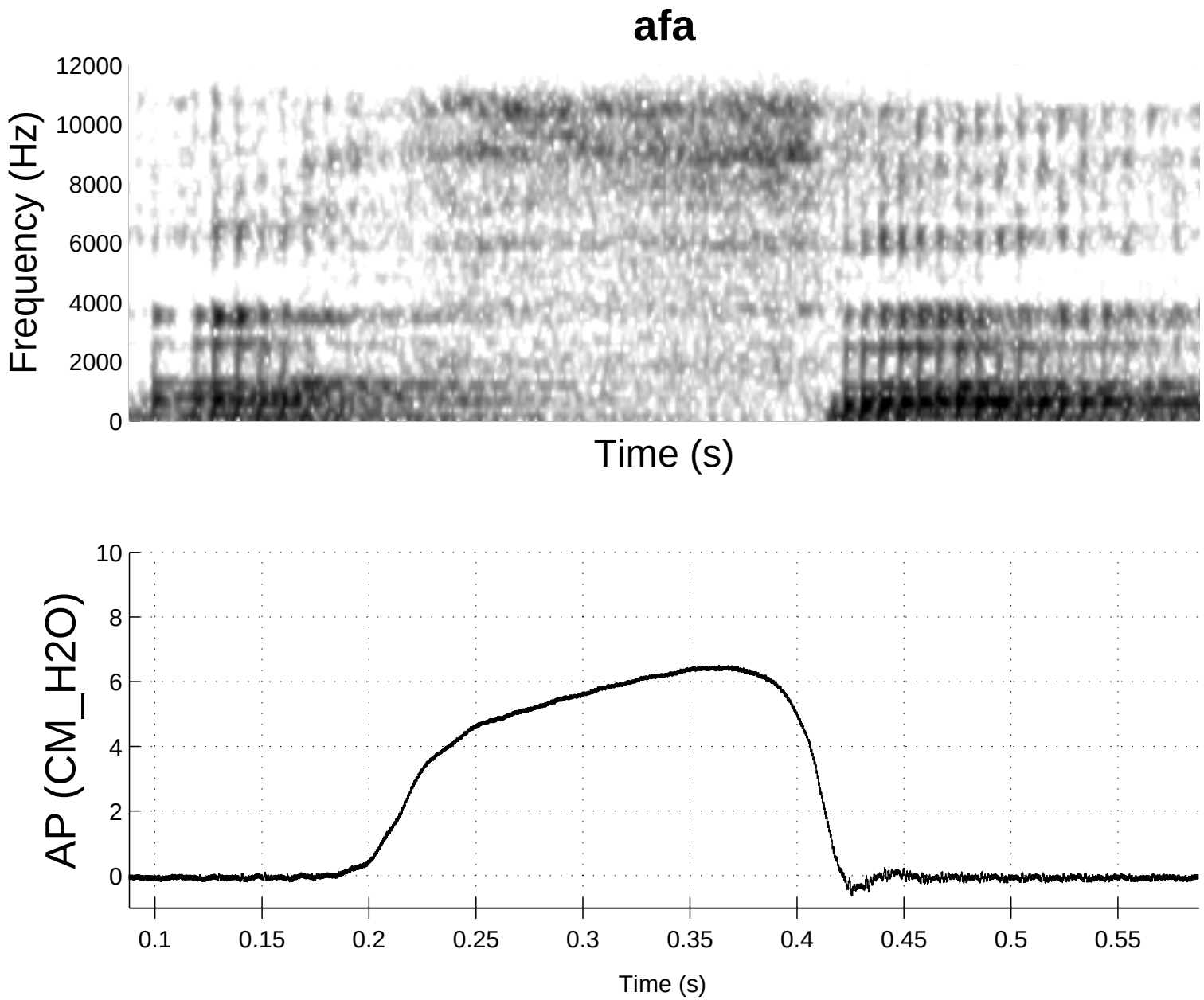
The most basic point is that oral air-pressure increases for fricatives just as it does for plosives, even though fricatives do not have complete closure.

The increased air-pressure is actually ***essential,*** in order to drive the air through the narrow constriction, causing the frication noise.

Accordingly, the frication for the /f/ does not become really noticeable in the sonagram until the air-pressure has risen to about 4cmH2O (at about 0.225s on the time axis) and then becomes weaker when the pressure drops at the end (at about 0.4s on the time axis).

Again, the peak air-pressure is very similar to that for the voiceless plosive in example 1.

The main difference from the plosive is that the rise at the beginning (and fall at the end) is more gradual, due simply to the fact that closure at the lips is not complete, so the flow of air out of the mouth slows down the rise in pressure.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Time (s)

5. Voiced fricative

The voiced fricative shows a particularly slow rise in the air-pressure.

This can be seen as a combination of the effects already discussed for the voiced plosive (vocal folds remain adducted) and the voiceless fricative (incomplete closure allows leakage of air out of the mouth).

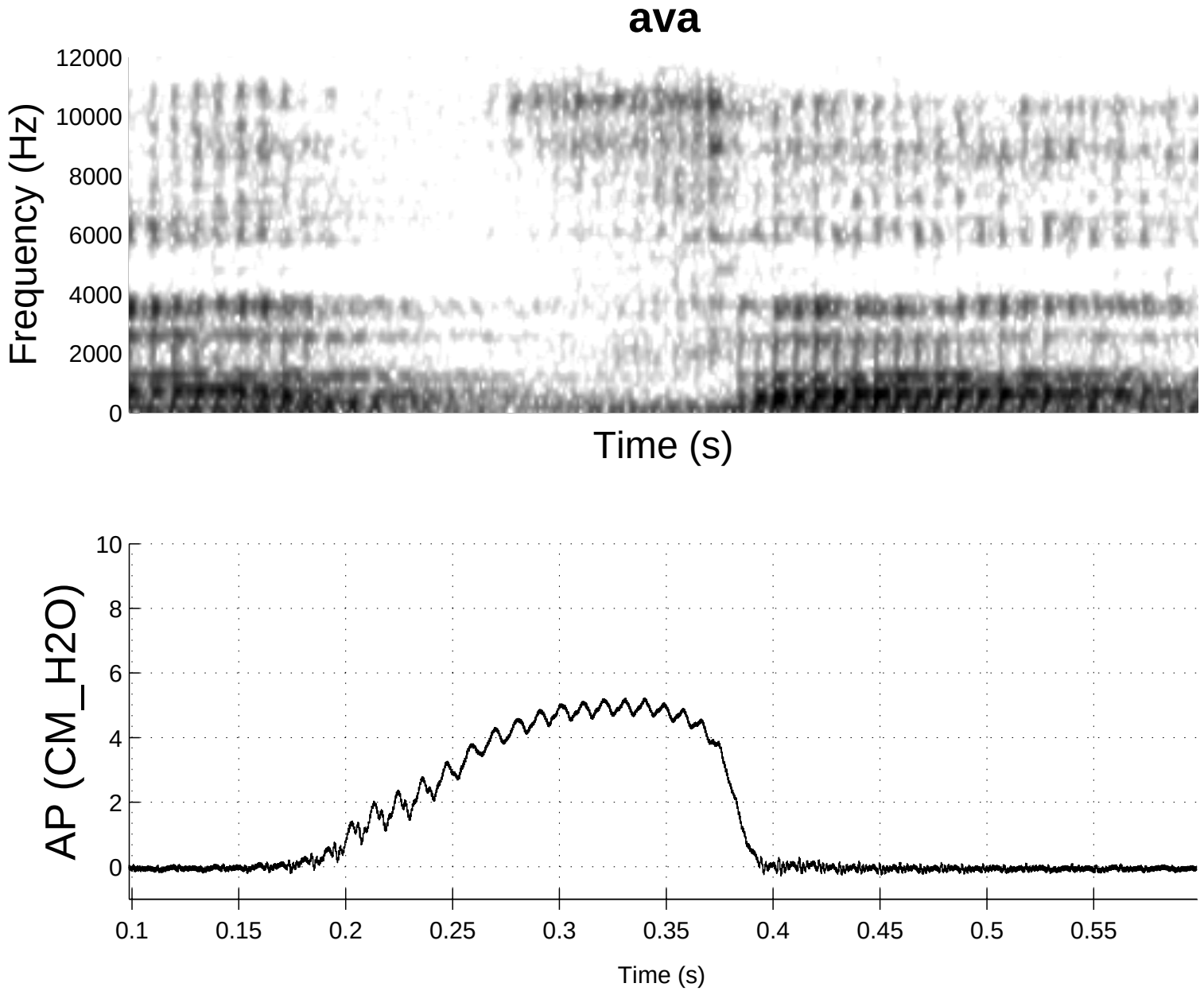
Accordingly, it takes quite a long time for air-pressure to increase enough to cause frication.

Note the long gap in energy at the higher frequencies in the sonagram at around 0.25s on the time axis.

This illustrates why voiced fricatives are often regarded as aerodynamically unstable sounds:

If air-pressure does not increase enough there will be no frication
If air-pressure increases too much voicing will not be possible.

In this particular case, air-pressure does not increase quite as much as for the other consonants and voicing actually continues more or less uninterrupted though the /v/.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Time (s)

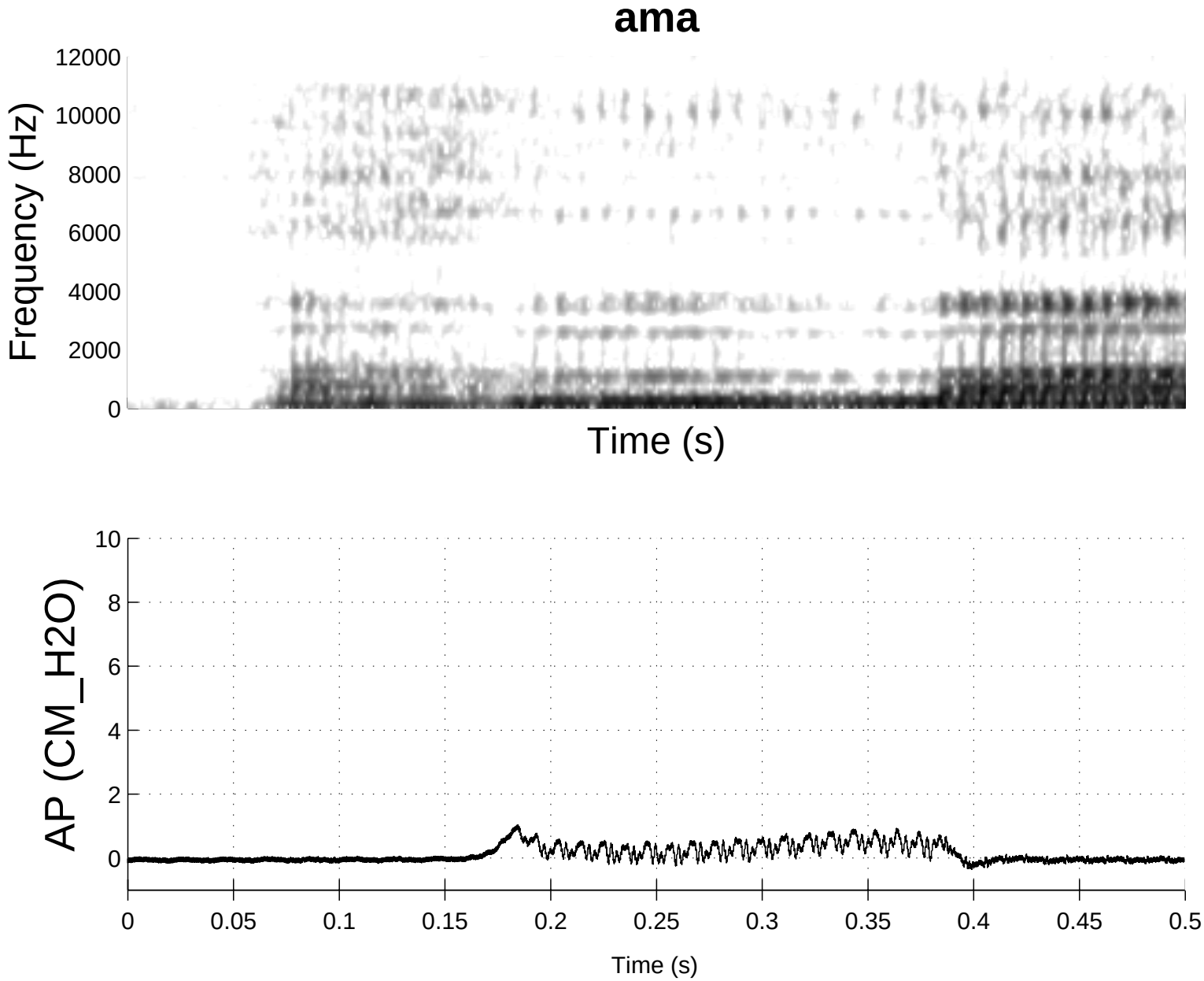
6. Nasal /m/

Just as a reminder:

NO increase in oral air-pressure for nasal consonants

Soft palate (velum) is lowered, allowing unimpeded passage of air through the velopharyngeal port.

Thus voicing can be maintained indefinitely in a nasal (‘mmmmm’), but not in a voiced plosive.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