

High-speed films of the lips

Movement and its aerodynamic consequences

Lip movements were filmed at 200 frames per second using a special high-speed video system.

Here we show three examples of simple VCV sequences (extracted from longer repetitive sequences like apapapapa).

Each example is available in two versions:

1. with full temporal resolution, set to play at 6 frames per second (i.e slowed down by a factor of about 33)
2. a “real-time” version which plays with audio at the original speaking speed but does not show all frames (this version is just intended to give an idea of what was spoken)

Click on the links highlighted in red to choose a film to view.

The following notes refer to the second and millisecond timer in the top right of the image.

/apa/

full resolution

real-time

After lip closure is achieved (at around 14.345s), the lips continue to move, i.e tissue is compressed. Thus when the lower-lip starts to move down (14.425) the lips do not immediately open, but rather start to decompress. This means that by the time the upper and lower-lip part (14.475) the lips are moving at close to their maximum velocity. This in turn means that the lip-opening area - which is the aerodynamically relevant feature of the movement - changes from zero to a large proportion of its maximum area within the space of just a couple of frames (i.e about 15ms).

These remarks may seem so obvious that one could have based them on introspection, rather than on an expensive video system. However, this simple example may help to reveal a fundamental point about the efficiency of speech communication: Since the speech organs like the lips are flexible rather than rigid, smooth movement (i.e with low accelerations, and thus low force input) can nonetheless result in abrupt modulations of the aerodynamics and the resulting acoustics. Clear modulations such as these probably have particularly high signalling value for the listener.

/upu/

full resolution

real-time

This sequence makes the same point as for /apa/. Here the pattern of a sudden change from zero lip opening to maximum area within a couple of frames (17.740 to 17.750) is actually even clearer: once again the underlying movement is smooth and continuous.

/ifi/

full resolution

real-time

By way of contrast, with a fricative as consonant a different movement pattern results. As the fricative requires a precise constriction it cannot take advantage of compression of the lip tissue to permit continuous movement through the consonant, so there is a period from about 40.410s to 40.480s where movement more or less ceases. This illustrates why fricatives are often considered more difficult to articulate.