The Relationship Between Pressure and Volume

An important law governing the behaviour of gasses is Boyle's Law:

$$PV = kNT$$

where:

P = pressure

V = volume

k = a universal constant

N = the number of molecules of the gas

T = the temperature of the gas

If we are dealing with a closed system, in which no gas enters or leaves, we may consider N to be a constant. Furthermore, if we are not dealing with externally imposed changes of temperature and any changes in pressure or volume are not so radical as to bring about changes in temperature, we may consider T also to be a constant. In this case, we may rewrite Boyle's Law as:

$$PV = K,\ where\ K\ =\ kNT$$

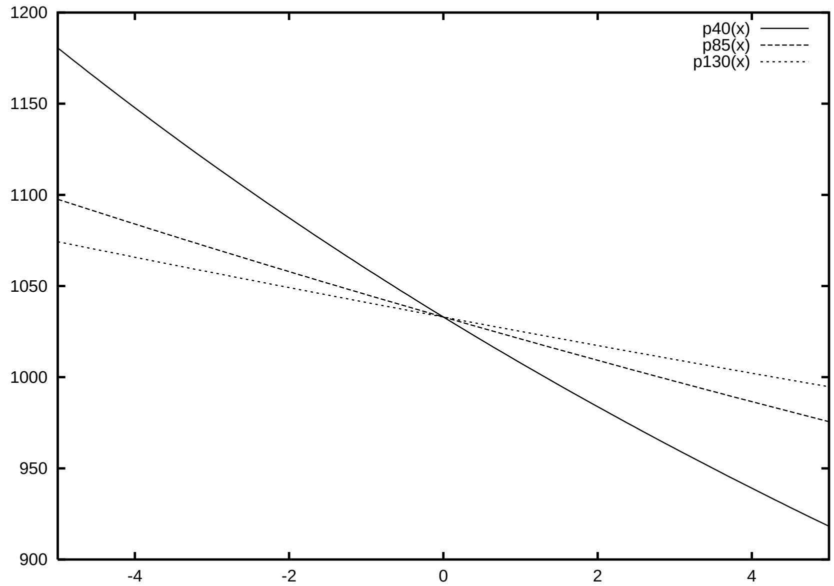
If we consider the same gas at the same temperature at two different pressure/volume combinations, we have:

$$P_1V_1 = K = P_2V_2$$

We may solve this for P_2 to obtain an expression for the pressure resulting from a change in volume.

$$P_2 = \frac{P_1V_1}{V_2}$$

In the following graph we have plotted pressure (in cm H_2O) as a function of change in volume for three initial volumes: 40 cm^3, 85 cm^3 and 130 cm^3.



Pressure as a Function of Change in Volume

These initial volumes each lie within the range of volumes of the oral tract for a major point of articulation. These ranges are as follows:

POA	volume (cm^3)
labial	$120 - 160$
alveolar	$70 - 100$
velar	$30 - 50$

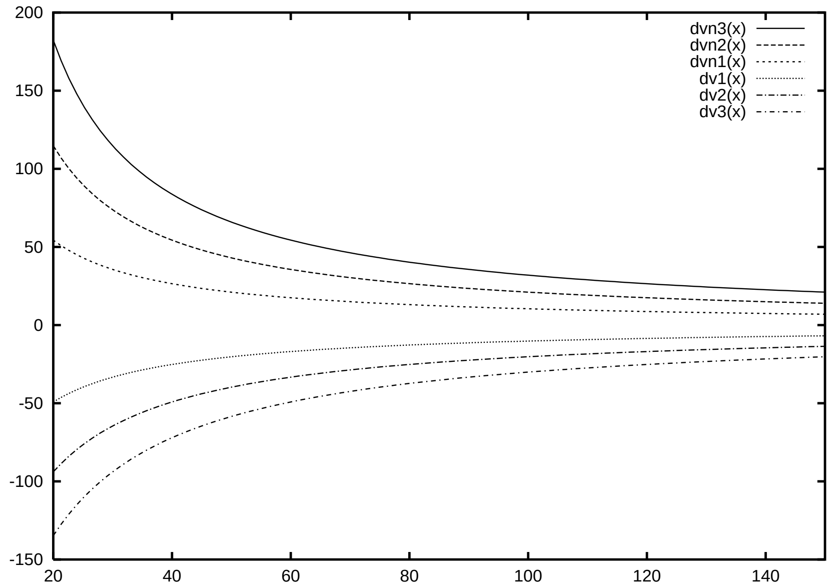
We see that increasing the volume decreases the pressure and conversely. We can also see from the above graph that a given change in volume causes less of a change in pressure the larger the initial volume. Let us compute the change in pressure explicitly.

$$\Delta P = P_2 - P_1 = \frac{P_1 V_1}{V_2} - P_1 = \frac{P_1 V_1 - P_1 V_2}{V_2} = \frac{P_1 (V_1 - V_2)}{V_2} = -1 \frac{P_1 (V_2 - V_1)}{V_2}$$

Letting $V_2 = V_1 + \Delta V$, we then have:

$$\Delta P = -1 \, \frac{P_1 \, \Delta V}{V_1 + \Delta V}$$

The following graph shows the relationship between the initial volume and the increment in pressure for six changes in volume. The initial pressure is set to atmospheric pressure. The changes in volume are: -3 cm^3 (labelled dvn3(x)), -2 cm^3 (dvn2(x)), -1 cm^3 (dvn1(x)), $+1$ cm^3 (dv1(x)), $+2$ cm^3 (dv2(x)), and $+3$ cm^3 (dv3(x)).



Dependence of Pressure Change on Initial Volume