Audiological Bulletin no. 31

The vent effect - an introduction

WIDEX®

high definition hearing

Introduction

Venting in earmoulds has been used for many years to control the sound pressure level in the ear canal at low frequencies and to make the hearing aid more comfortable to wear. Vents often reduce the occlusion effect and the build-up of moisture in the ear canal as they permit the passage of air into the ear canal. The effect of different vent sizes (diameters) has been described in litterature and many different styles and shapes of vents are available to make controlled adjustments to the sound characteristics of hearing aids in the ear canal.

In most modern hearing aids the sound pressure level can be controlled effectively with high frequency resolution in the hearing aid amplifier itself. This advanced technology reduces the need for controlling the sound pressure level using a special vent design. This leaves relief of the occlusion effect and improvement of wearer comfort as the main reasons for making vents in earmoulds or shells.

The hearing aid works to control the sound pressure level in the ear and provide the correct sound pressure level at the eardrum. But how can the hearing professional ensure that the sound pressure in the ear is as they prescribe?

Hearing aid manufacturers measure and set up the hearing aids to produce a specific sound pressure level based on an average hearing aid user's ear canal and the individual user's hearing loss - using a closed earmould. But as the real-life hearing aid may be fitted with an earmould that is not closed but equipped with a vent or an open fitting, the expected sound pressure at low frequencies is reduced according to the degree of openness. The amplification provided by the hearing aid has to compensate for this individualisation of the earmould or shell.

For this to be possible, the fitting software needs to know the actual effect of the vent in the individual real-life earmould.
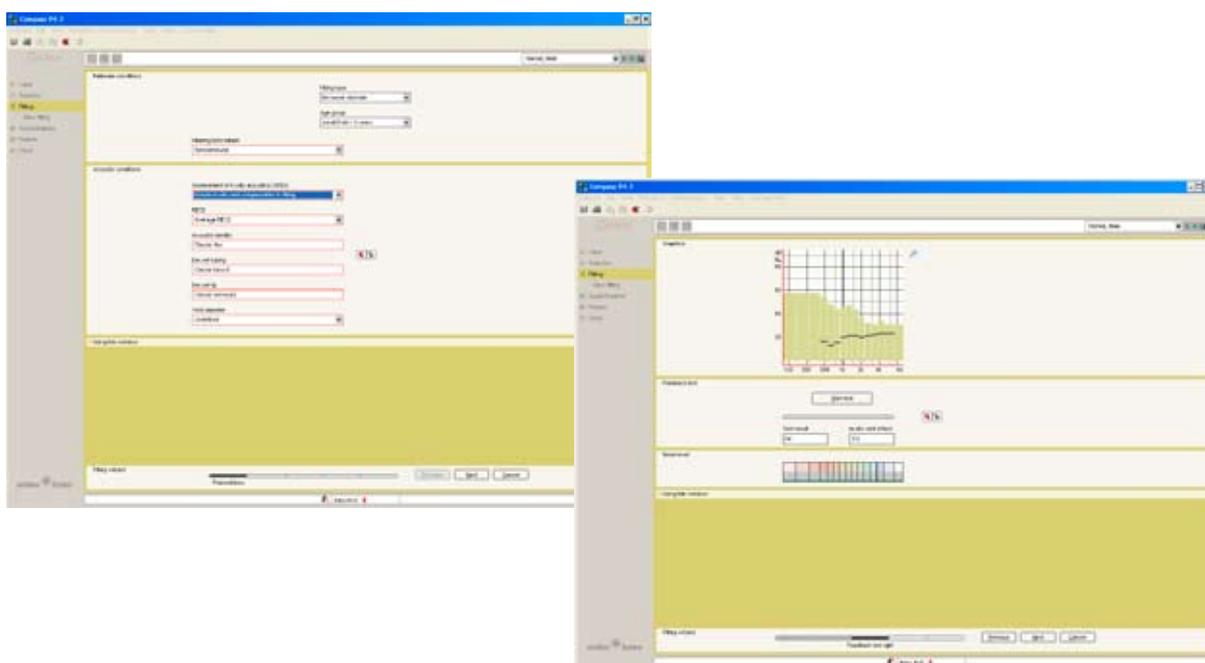
The vent effect

When creating a vent, which is basically making a hole through a closed earmould to be placed in the ear of a hearing aid user, the sound pressure level in the ear canal changes. How big this change is depends mainly on the dimensions of the hole and the residual volume of the individual ear, that is the air-filled space between the earmould and the eardrum.

The change in sound pressure level also depends on the source of the sound. This means that the change in sound pressure for sound coming from the hearing aid is different from that for sound coming from, for example, the hearing aid user's own voice. When we talk about the "vent effect", it is the effect of the vent on the sound generated by the hearing aid.

Figure 1 shows the vent effect for a closed earmould (0 mm) and three different vent diameters in an average ear. With an increasing vent diameter, the sound pressure falls for the low frequencies. In this example the damping of the sound from the hearing aid due to a 3mm vent is 23dB at 200Hz. The figure also shows that the vent leads to an increase in the hearing aid gain at some frequencies. The 3mm vent in this average ear will increase the sound level from the hearing aid by about 7dB at 800Hz.
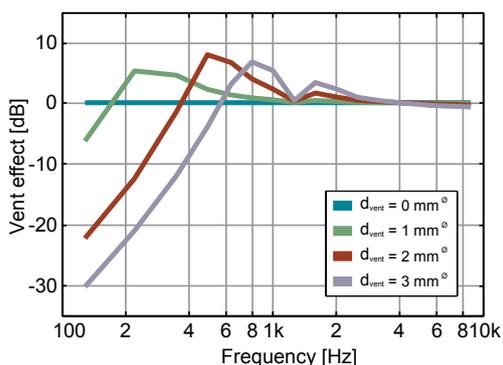
Figure 1: Shows the vent effect for different vent diameters.

This means that the fitting software for the hearing aid should be able to handle the effect of the vent to be able to calculate the correct amplification of the hearing aid for the individual user and hearing loss.

Vent dimensions: Diameter and length

In general terms, what defines the vent effect is the cavity in the ear and the opening to the external environment made by the vent. At this stage we enter the world of basic physics. The vent and the residual volume of the ear canal can be seen as a closed cavity with an opening in one end, like a bottle with a bottleneck. The dimensions of the bottle determine the frequency at which damping of the low frequency content in the cavity will start to occur. This frequency is called the resonance frequency. This is the frequency of the tone you will hear if you blow over the top of such a bottle. In physical terms, a system consisting of a cavity and an opening of a certain length and diameter is called a "Helmholtz resonator". You see this in musical instruments as well as in loudspeakers and room acoustics.

The calculation of such a system's resonance frequency has been described by the physicist Helmholtz (1860) and is therefore called the "Helmholz frequency".

The Helmholtz resonance

The Helmholtz resonance describes the phenomenon of air resonance in a cavity, here a bottle. The resonance frequency of a bottle is defined as:
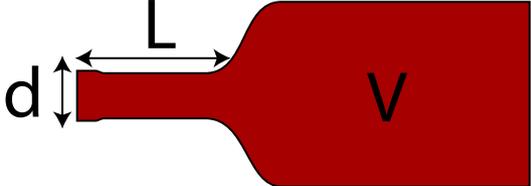
$$f = k \cdot \sqrt{\frac{d^2}{L \cdot V}}$$

Figure 2: A bottle as an example of a Helmholtz resonator.

where k is a constant[1], d is the diameter of the opening, L is the length of the opening and V is the volume of the bottle cavity.

If the diameter, length or volume (d, L or V) changes, the resonance frequency of the bottle changes too.
- If the diameter of the bottle (d) is made larger, the resonance frequency will be higher.
- A longer bottle neck (L) will lower the resonance frequency.
- A bigger bottle cavity (V) will lower the resonance frequency.

How does this compare to the situation of a hearing aid and an earmould placed in an ear? The vent in the earmould can be seen as the neck of the bottle and the residual volume of the ear canal as the cavity in the bottle.
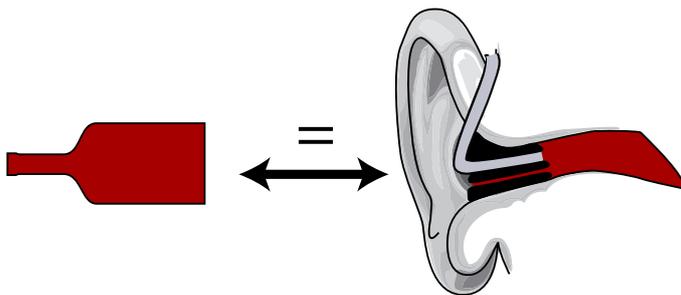

Figure 3: An ear canal with an earmould or shell is also a Helmholtz resonator.

---

[1] $k = \dfrac{c}{2\sqrt{\pi}}$ where c is equal to the speed of sound

Let us look at what this means for two cases:

- A larger residual volume (V in this example) leads to a lower resonance frequency and thus a decreased vent effect.
- A longer vent (L) also leads to a lower resonance frequency and thus a decreased vent effect.
- A larger diameter of the vent (d) will lead to an increased vent effect.

You can see the vent effect in Figure 4, where the effect of a 2mm vent on an average ear is shown for the vent lengths of a standard earmould (approx. 18 mm) and a custom élan earmould (approx. 2 mm) to the left and ear sizes (large, medium, small) to the right.
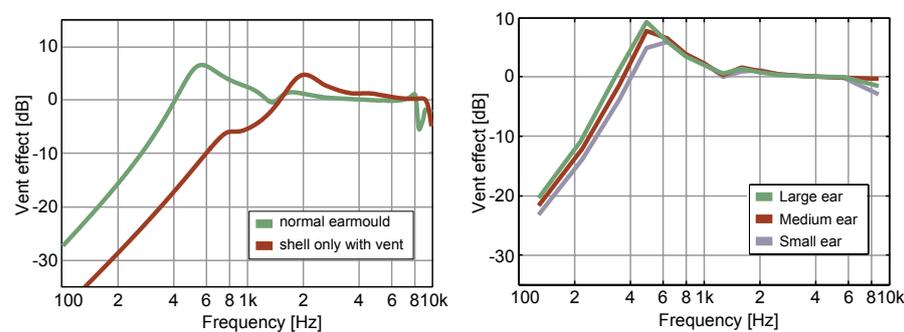

Figure 4: Vent effect for long and short vents and for small, medium and large ears.
The vent effect in this figure is shown for different vent lengths on the left
and for different residual cavity sizes with a standard earmould
on the right. The vent size is 2 mm and all other parameters are average.

Summary

The vent diameter alone is not enough to predict how the sound pressure level in the individual ear canal differs from the expected sound pressure in an average ear. Intended and unintended leakages and further parameters / factors may have a large effect on the actual sound pressure in the ear canal that the fitting software has to take into account for the hearing aid to provide the gain needed in order to perform optimally for the individual user. Therefore it is essential for a precise fitting that the fitting software can assess correctly the actual acoustic situation in the ear of the user.