

Effective Feedback Cancellation Enables Open Ear Fittings

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Hearing aids with open-ear fittings or wide vents are susceptible to feedback oscillations.

A feedback canceller provided 15 dB of added stable gain and enabled a greater range of hearing losses to be fitted effectively for open ears and ear moulds with vents.

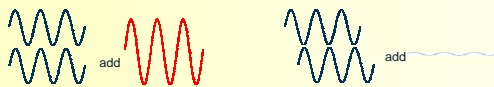
Feedback cancellation was more effective at reducing the incidence of feedback than an alternative adaptive feedback suppression algorithm.

Acoustic Feedback

One of the barriers to hearing aid use, particularly among hearing impaired people with mild low frequency hearing loss, is the sensation of having blocked ears and the subsequent dissatisfaction with the sound of their own voice. The main reason for blocking the ear canal is to reduce the likelihood of the hearing aid output sound from re-entering the microphone and creating feedback oscillation.

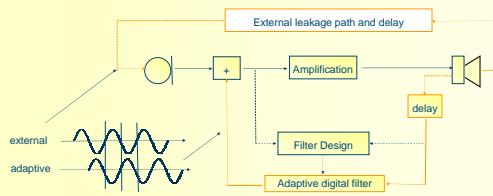


If two signals are in phase when the waves are added, the resultant signal will increase. If two signals have opposite phase when they are added, the resulting signal will be smaller.



Thus, if the delay around the feedback loop (through the hearing aid, into the ear canal, and back to the microphone) is a whole number of wavelengths, and the gain around the loop is greater than one, the output signal will be continually added to the input in phase, and an oscillation will occur.

Two alternative methods of dealing with feedback oscillations are called Adaptive Feedback Suppression (AFS) and Adaptive Feedback Cancellation (FBC). AFS searches for oscillations and reduces the gain at the appropriate frequency when an oscillation is detected. FBC models the feedback path inside the hearing aid, and subtracts the modeled feedback signal from the microphone input signal to cancel the acoustic feedback.



STUDY DESIGN

The goal of the study was to determine approximate fitting ranges for hearing aids with AFS and FBC for open fittings and conventional ear moulds.

Participants: A total of eleven volunteers with impaired hearing participated in the study (7 women and 4 men aged 30 to 84 years). The volunteers were carefully chosen to ensure that a range of hearing losses and hearing loss configurations were represented. The hearing losses ranged from mild to severe. Some were flat, some mildly sloping and some steeply sloping. All volunteers had sensorineural hearing losses in both ears.

Hearing aids: Each participant was fitted with two ADRO BTE hearing aids configured with three programs: two experimental programs and a telecoil program. Both experimental programs had adaptive directional microphones and expansion to reduce circuit noise in the hearing aids. One experimental program included feedback cancellation (FBC) and the other had either adaptive feedback suppression (AFS), or no processing to avoid feedback. The program used for FBC was balanced across the volunteers (half in program 1 and half in program 2). The volume controls were disabled for the duration of the study to provide consistent gain and output levels in all experimental programs.

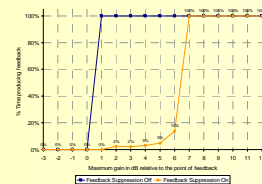
Ear moulds: There were three groups of volunteers. Three wore vented ear moulds with the BTEs containing AFS and FBC, five wore open ear fittings with the BTEs containing AFS and FBC, and three wore vented ear moulds with the BTEs containing only FBC.

Procedure: Each volunteer received a binaural ADRO hearing aid fitting with a fixed volume control. In the event of feedback occurring during the fitting, the maximum gain was adjusted in the frequency region of feedback. This adjustment was made in the two experimental programs individually. Maximum gain differences between the two programs were recorded. Over a period of two to five weeks of take-home use, each volunteer compared the two experimental programs in a variety of situations. They were given questionnaires to help identify whether one program was more likely to feed back than another.



Instrumental measurements of FBC and AFS

The amount of added stable gain (ASG) for the FBC was determined to be 15 dB. ASG is defined by the difference between the maximum amount of gain achievable before feedback occurs with the FBC turned on and the maximum amount of gain achievable before feedback occurs with the FBC off. These measurements of ASG were made using a BTE hearing aid placed on a Head and Torso Simulator (HATS) in a sound booth. 15 dB of ASG enables the fitting of greater degrees of hearing loss without feedback and increases the potential for both open fittings and venting in ear moulds and custom aids.

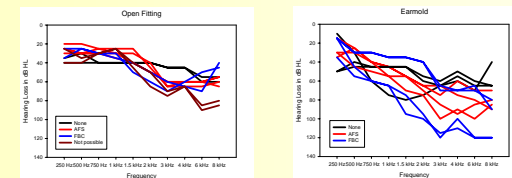


AFS operates on a different principle from FBC. It does not provide added stable gain, but searches for oscillations and reduces gain in a narrow frequency range if oscillations are detected. Instrumental measures of AFS were made by setting the gain of the hearing aid to the point where feedback first occurred (labelled 0 dB) and then recording the output of the hearing aid for gain settings at 1 dB intervals. The percentage of time that oscillations were observed in the recordings is shown in the figure for a maximum gain reduction of 6 dB. The AFS used in the study had a maximum gain reduction of 12 dB.

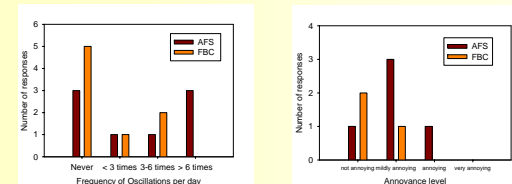
RESULTS

At the time of fitting, there was only one participant who needed a gain reduction as well as the FBC in order to achieve an acceptable fitting. There were also two others who required a gain reduction to achieve an acceptable fitting with AFS. All three were in the open fitting group. At the end of the study, the 11 participants were classified according to their need for AFS and FBC. Those participants who reported no oscillations with either program were classified as AFS or neither (depending on which hearing aid they used in the study). Participants who reported oscillations in both programs were classified according to which program they preferred (not always the one with the least incidence of oscillations).

	Open fit	Vented (AFS & FBC)	Vented (FBC only)
Neither AFS nor FBC	1		2
AFS	2	2	
FBC	1	1	1
Gain reduction + FBC	1		



The audiograms of the participants are colour-coded according to their AFS and FBC requirements above. There is considerable overlap in the groups for both open-fitting and vented ear moulds. **Questionnaires:** Volunteers were requested to record the number of times per day they experienced feedback, how annoying this feedback was and under what conditions they were most likely to experience feedback in each of the two programs. Overall, volunteers experienced feedback less often with the FBC and were less likely to be annoyed by the feedback than in the control conditions.



The top two graphs show the results for the 8 participants who used AFS and FBC. The lower graph shows results for the 3 participants who used FBC only. The latter group responded to the questionnaire on 3 occasions during their 5-week trial of the hearing aids.

CONCLUSIONS

- The FBC enabled effective open fittings and vented ear moulds for participants who would otherwise have had problems with feedback.
- FBC lowered the incidence of feedback oscillations and reduced annoyance.
- There is considerable overlap in the fitting ranges for open fittings and vented ear moulds, and for AFS and FBC. Collection of further data is needed to better define the fitting ranges.