# SIGNAL-TO-NOISE RATIO IN VARIOUS FM CONFIGURATIONS Heidi Peeters, M.A., Francis Kuk, Ph.D., Petri Korhonen, M.Sc. (Tech.), Bryan Crose, B.S. Widex Office of Research in Clinical Amplification (ORCA), Widex USA

## INTRODUCTION

Performance of FM systems in noise can be influenced by the microphones used (FM only, FM+M, or hearing aid only) and their respective settings. Each FM setting has limitations when listening in noisy environments and compromises are made to improve the signalto-noise ratio (SNR). While the FM only condition has been shown to provide the best SNR (e.g. Hawkins, 1984) it is still desirable to use the system in the FM+M mode so that the affected child can hear speech from directions all around him/her and is in this way given a better chance at incidental learning, has the abilities to interact more with classmates, and is also still able to hear the teacher with good SNR. While FM alone settings provide the greatest SNR advantage the use of the FM+M mode may also be able to supply a similar SNR advantage with changes to the DAI gain of the FM microphone.

## METHOD

#### Participants

Twenty adults with bilateral sensorineural hearing loss participated in the study (10 males and 10 females). Of the 20 participants 6 had a mild-to-moderate sloping hearing loss, 1 had a moderate reverse slope, 6 had a moderate flat hearing loss, and 7 had a precipitous hearing loss (Figure 1). All participants were native English speakers. Fourteen participants had previously worn hearing aids while the remaining 6 had not previously worn hearing aids. Their ages ranged from 52 to 88, with a mean age of 72 years.

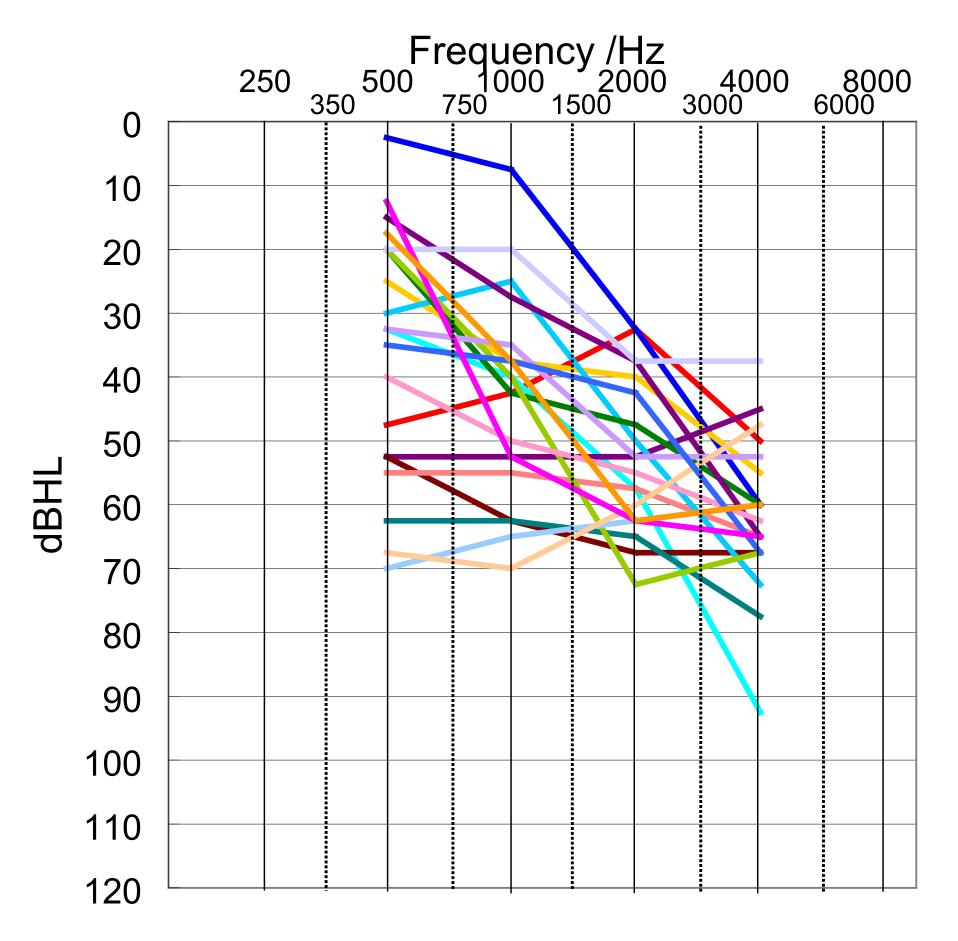


Figure 1: Insert earphone thresholds averaged for left and right ears and plotted for each participant.

#### Hearing aids

Listeners were fit binaurally with CAMISHA vented molds and the Widex Inteo 9 or open fittings with the Inteo élan hearing aids. Compass v4.4 was used to program the hearing aids. Inteo is a 15 channel hearing aid with an input dynamic range of 107 dB SPL, a compression threshold as low as 0 dB HL, and an active feedback cancellation algorithm that estimates feedback in each of two microphone paths.

## METHOD (continued)

#### FM system

The Widex SCOLAteach FM system lapel microphone was used in conjunction with the SCOLAflex FM boots. The SCOLAteach is a narrow band (50 kHz channel bandwidth) radio transmitter which works with the SCOLAflex FM receiver. It has a bandwidth of 100-7000 Hz using an omnidirectional lapel microphone. The SCOLAflex receiver has a bandwidth of 100-6500 Hz and a gain range of 30 dB (-16 dB and +14 dB), taken in 2 dB step sizes.



Participants were fit with the hearing aids and then wore them home for one month before testing. HINT (Hearing in Noise Test) sentences were presented to listeners through a speaker located 3 m away at 0° (in front) with continuous HINT noise at azimuths of 90°, 180°, and 270° placed 1 m from the listener at an overall output level of 68 dB SPL. The Widex SCOLAteach FM system lapel microphone was placed in front of the 0° speaker 12.5 cm in front of the speaker woofer. HINT tests and FM/hearing aid conditions were counterbalanced. HINT noise at 68 dB SPL was presented for 30 seconds before speech began. The level of the signal reaching the hearing aid through FM transmission was amplified or reduced by adjusting DAI (Direct Audio Input) gain in the Compass Figure 2: FM transmitter with software. Each participant completed one list for each of the following attached lapel microphone and listening conditions: hearing aid (M only) omnidirectional without noise layout of the hearing aid with the reduction, FM only (0 DAI offset) without noise reduction, and FM+M receiver pieces ready to be attached. omnidirectional without noise reduction (DAI offsets of +6 dB, 0 dB, and -6 dB).

### Classroom set-up

The test room was 40'3" x 20'11". The 0° speaker was placed 3 m from the participant throughout speech performance testing. Reverberation time of the room was measured to be 0.4 s using white noise. The FM microphone was placed at a distance of 12.5 cm from the speech speaker (0°) woofer. The SCOLA teach transmitter was placed on top of the speaker (Figure 3).

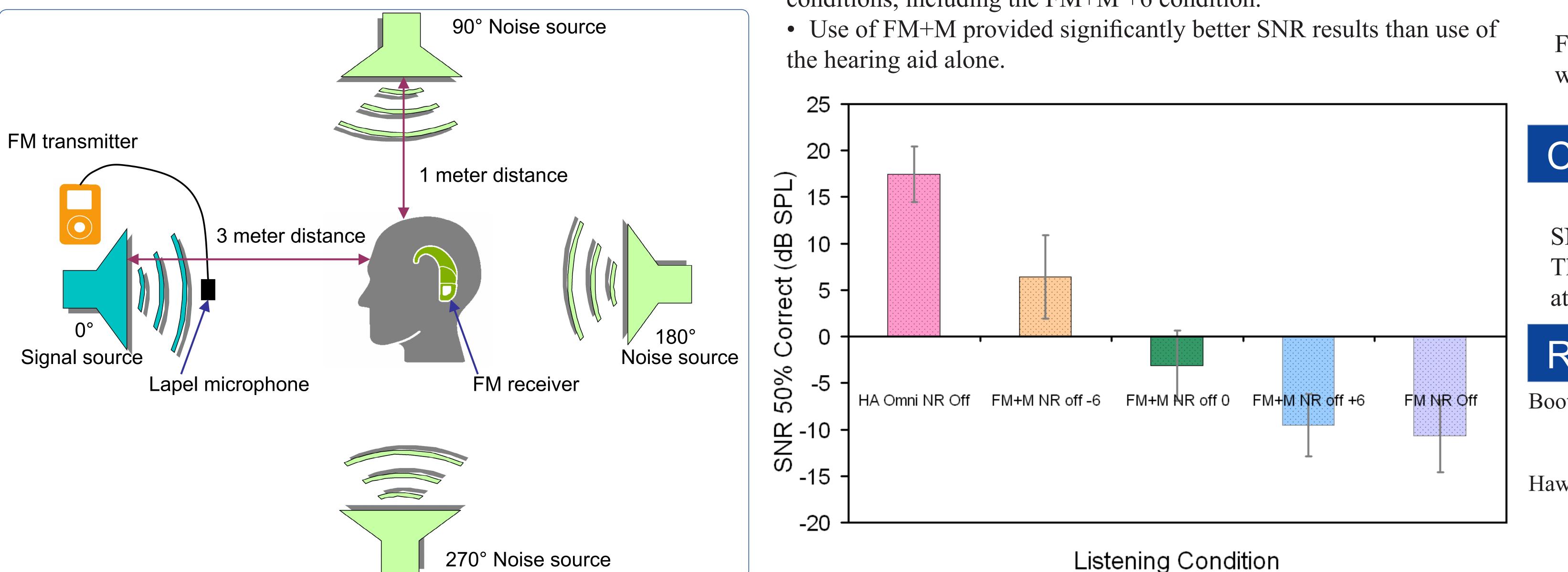


Figure 3: Speaker, FM system and participant arrangement within the classroom.

## METHOD (continued)

### Procedures

## RESULTS

Averages for all participants

• All conditions were subjected to paired sample t-test statistical analysis. Mean difference was significant if p<0.006 (with Bonferroni multiple pairs correction).

• When all participants were considered together each listening condition was significantly different from all other listening conditions. For example, the FM only condition was significantly better than all conditions, including the FM+M +6 condition.

Figure 4: Average HINT scores for all participants with stimulus at 0° from a 3 m distance under different FM conditions.

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> Figure 5: Average HINT scores for open and flex vent fittings with stimulus at 0° from a 3 m distance under different listening

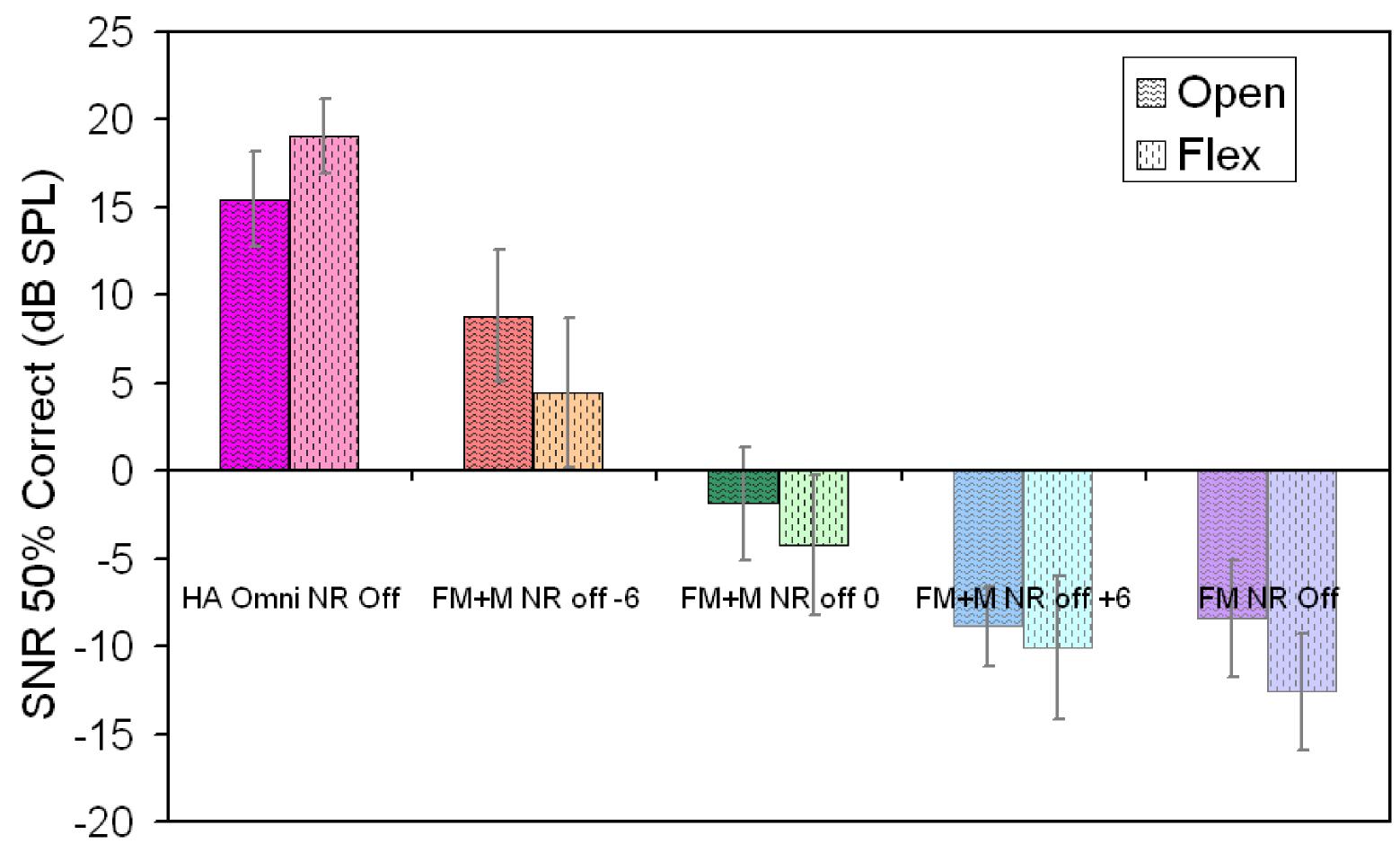


## RESULTS (continued)

#### Open fittings vs. flex vent fittings

• Performance was significantly better for open fittings than flex vent fittings when using the hearing aid alone (df = 8, t = 3.830, p < 0.01). • SNRs were better for flex vent fittings than for open fittings when the FM system was used (FM+M and FM only). The difference was significant for FM+M -6 NR off (df = 8, t = -2.538, p < 0.05).

• When participants were divided into an open fitting group and a flex vent group no significant differences were found between FM+M +6 and FM only conditions.



Listening Condition

## CONCLUSION

In order to achieve FM+M SNRs that are equally as good as FM only SNRs the DAI gain on the hearing aid needed to be turned up to +6 dB. This was true across listeners with various hearing loss configurations at a 3 m distance from the signal of interest.

## REFERENCES

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