Fitting WDRC Devices: Which Rationale and How Many Channels?

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INTRODUCTION

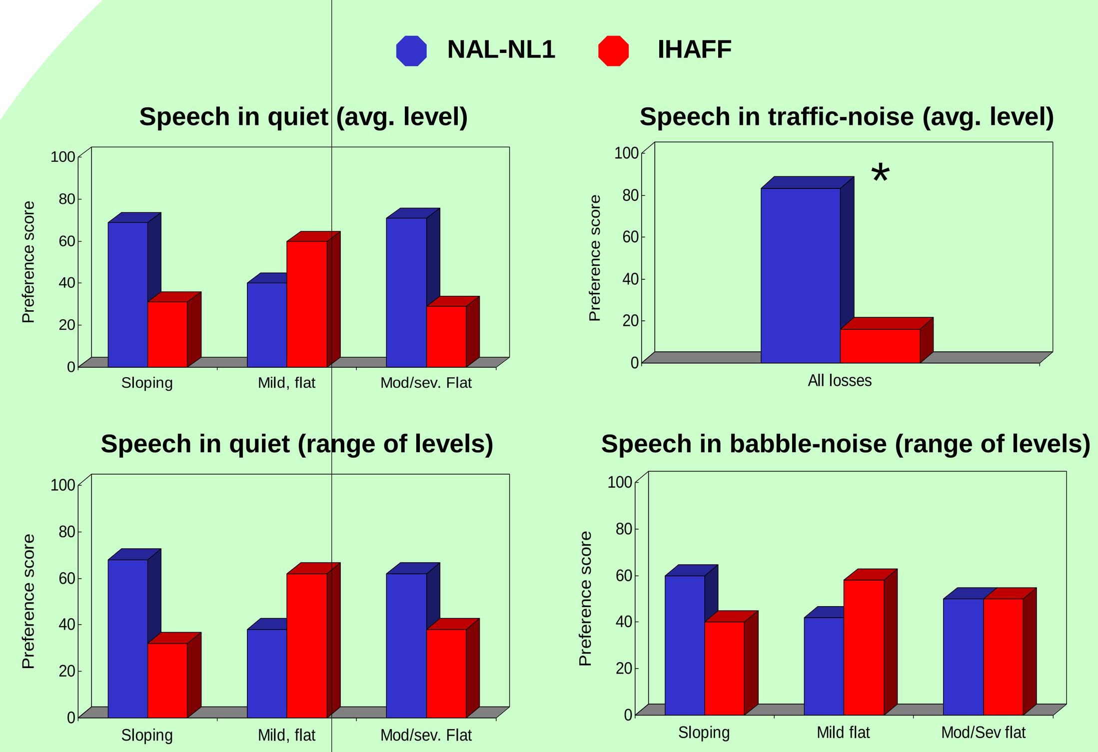
Wide Dynamic Range Compression (WDRC) hearing aids are believed to be the best remedy for recruitment, which is experienced by most hearing impaired people. There are at least two theories about how WDRC devices should be fitted. One theory is to Normalize Loudness in some way (e.g. LGOB, FIG6, IHAFF, DSL[I/o], and ScalAdapt), and another is to Maximize Speech Intelligibility (e.g. NAL-NL1). In some cases, the two rationales result in very different prescriptions. For example, Loudness Normalization prescribes significantly more low frequency gain than NAL-NL1 for people with flatter losses, and for people with steeply sloping losses Loudness Normalization prescribes more high frequency gain than NAL-NL1. It is currently uncertain which rationale is best for listening to the range of input levels that is presented in our everyday lives.

WDRC hearing aids are now commonly available with up to 20 channels in which gain and compression can be independently adjusted. In theory, multi-channel WDRC devices have at least two advantages over single channel devices: 1) The variation of a person's audible range can be better matched across frequencies, and 2) The SNR can be improved in situations where the noise is dominant in a restricted range of frequencies. The superiority of multi-channel compression over single-channel compression is, however, still controversial. Current evidence is mainly based on Loudness Normalization procedures. The NAL-NL1 procedure prescribes compression ratios lower than those prescribed by Loudness Normalization. High compression ratios are known to adversely affect intelligibility in multi-channel compression.

This poster presents data from a study that investigated whether hearing impaired people 1) prefer the rationale of Normalizing Loudness or Maximizing Speech Intelligibility, and 2) benefit from one, two, or four channels of compression when prescribed according to the NAL-NL1 procedure.

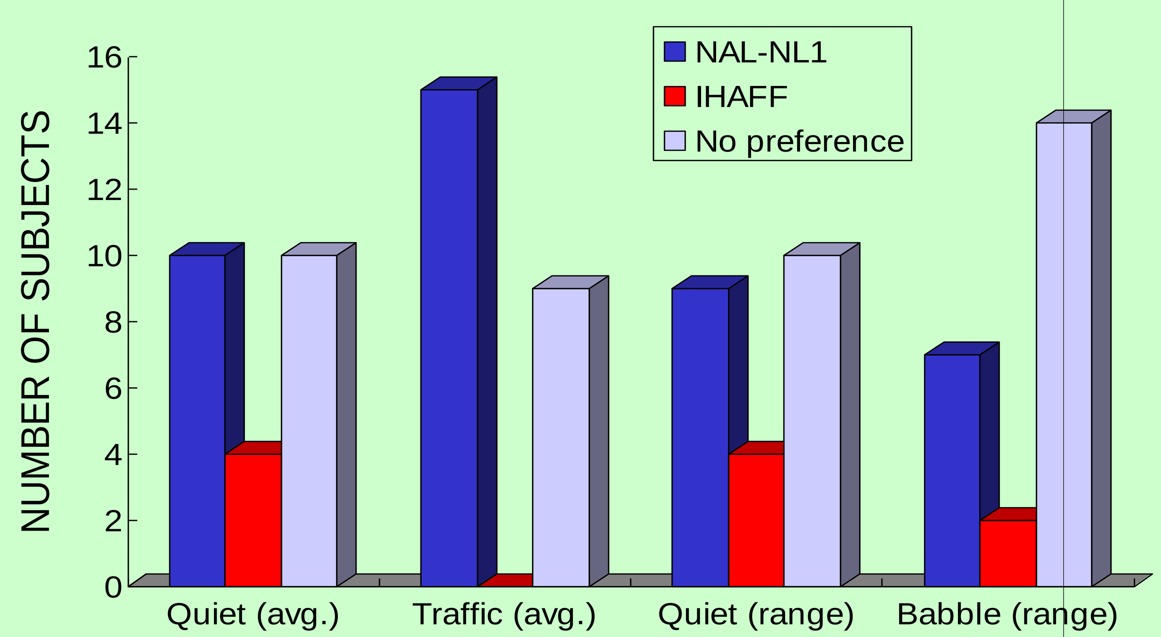
RESULTS 1 (Which Rationale?)

Paired Comparison



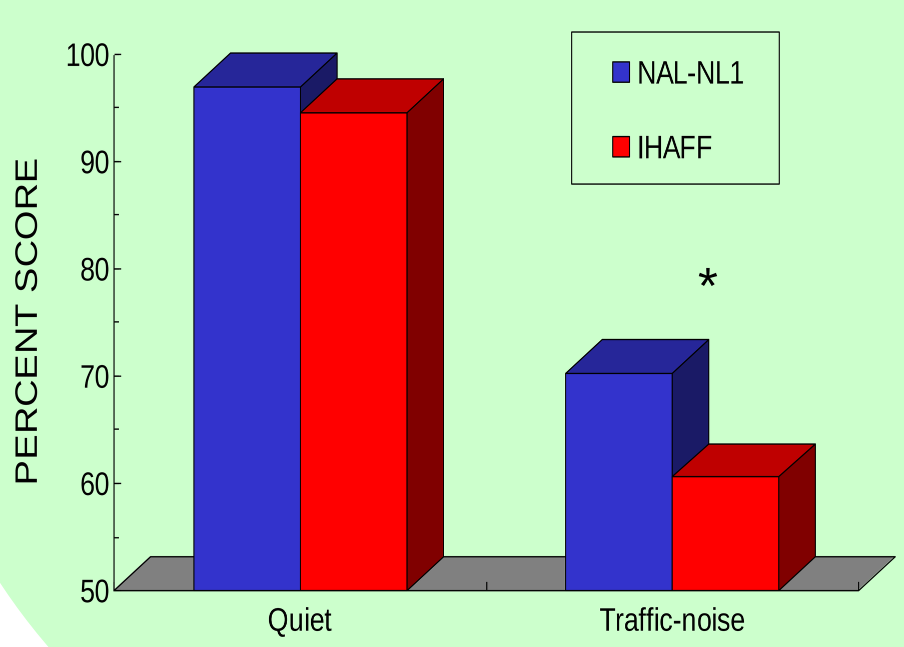
Average percentage preference obtained for each scheme in each of four listening conditions. An asterisk indicates that the difference between scores is significant. The subjects with mild, flat losses, who preferred IHAFF more often than NAL-NL1, listened to relatively small differences in the low frequency gain between the two responses compared to the remaining subjects with flat losses who preferred NAL-NL1 more often than IHAFF.

Paired Comparison



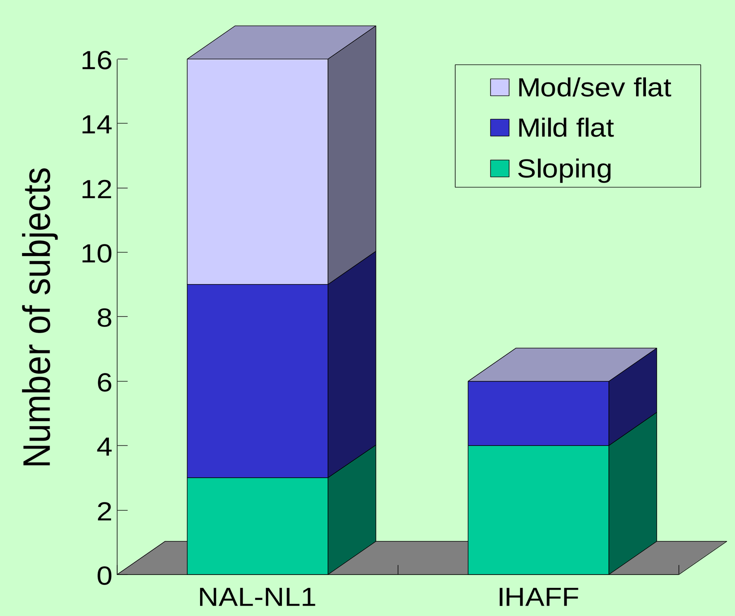
The number of subjects who showed a significant preference for one rationale over the other in each of the four listening conditions. Overall, more subjects preferred NAL-NL1 than preferred IHAFF.

Speech Recognition



Average percentage score obtained by each rationale. The difference in score obtained for speech in traffic-noise is significant (p = 0.04).

Field Test



The number of subjects who reported a preference for either rationale after the field test. Two subjects withdrew from the test. On average, the difference in gain between the two responses was greater for those who preferred NAL-NL1 than for those who preferred IHAFF.

CONCLUSION 1

When the responses prescribed by Loudness Normalization (IHAFF) and Speech Intelligibility Maximization (NAL-NL1) are significantly different, and the difference is achieved in insertion gain, hearing impaired people prefer the rationale of Maximizing Speech Intelligibility.

METHOD

Subjects

Twenty-four subjects participated in the study. Eight each had a steeply sloping loss, a mild flat loss, and a moderate severe flat loss.

Laboratory Tests

In the laboratory, the compression schemes were implemented in Knowles' Experimental Processor for Acoustic Research (KEPAR).

The subjects completed a Paired Comparison Judgement test to determine their preferred compression scheme with respect to clarity and ease of understanding speech, and a Speech Recognition test using BKB sentences.

The listening conditions were:
*) male speech,
*) male speech in traffic-noise (-9.8 dB SNR),
*) male speech jumping every three seconds among three different input levels (range: 20 dB), and
*) the jumping male speech in jumping babble-noise (SNR also varies with speech level).

Implementation

Loudness Normalization was implemented using the IHAFF protocol (Contour test/VIOLA) and Maximizing Speech Intelligibility was implemented using NAL-NL1. The two rationales were compared in two-channel schemes. Throughout the study, the overall gain of each scheme was adjusted to the subject's preferred listening level, and fast time constants were used.

Field Test

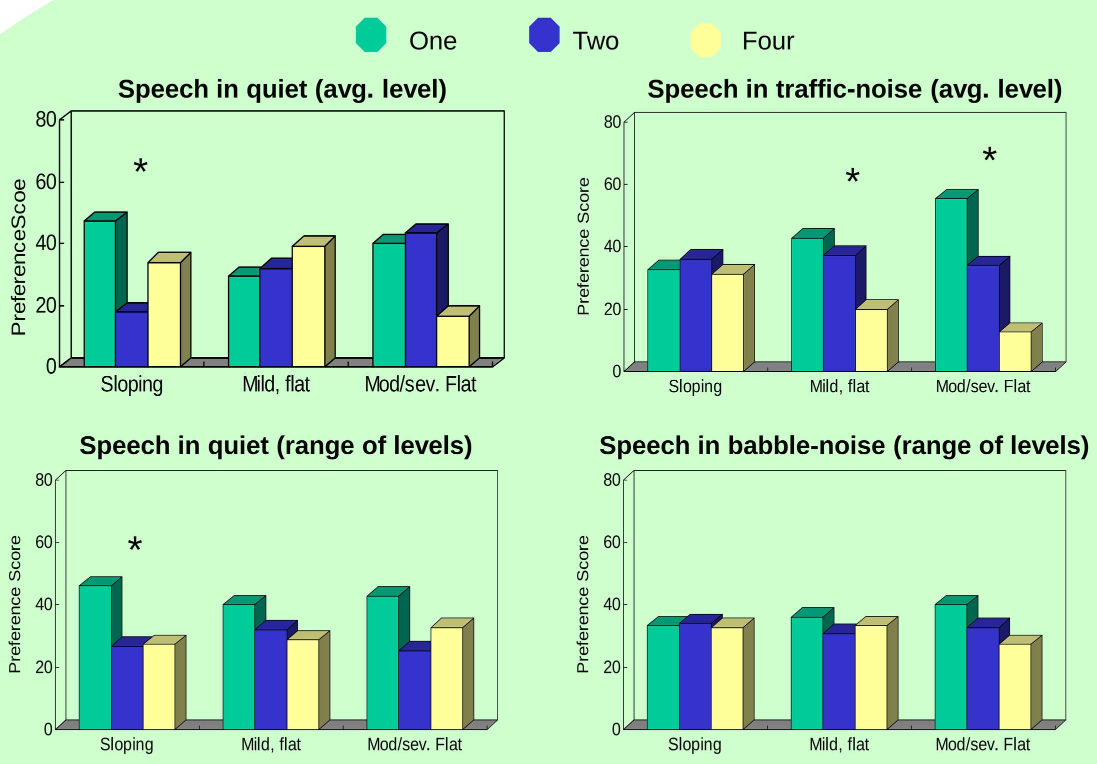
Oticon's digital two-channel, two-memory JUMP-1 device was used for the field test. Each subject completed two periods comparing:
*) NAL-NL1 versus IHAFF, both with two channels, and
*) one-channel versus two-channel, both using NAL-NL1.

The subjects compared two schemes for 4-6 weeks in individually selected everyday listening situations. On a diary form, they rated the satisfaction with each program on a scale from 0-10 and gave a description of each program.

Each test period was completed with an interview about the overall experience with each scheme and preference.

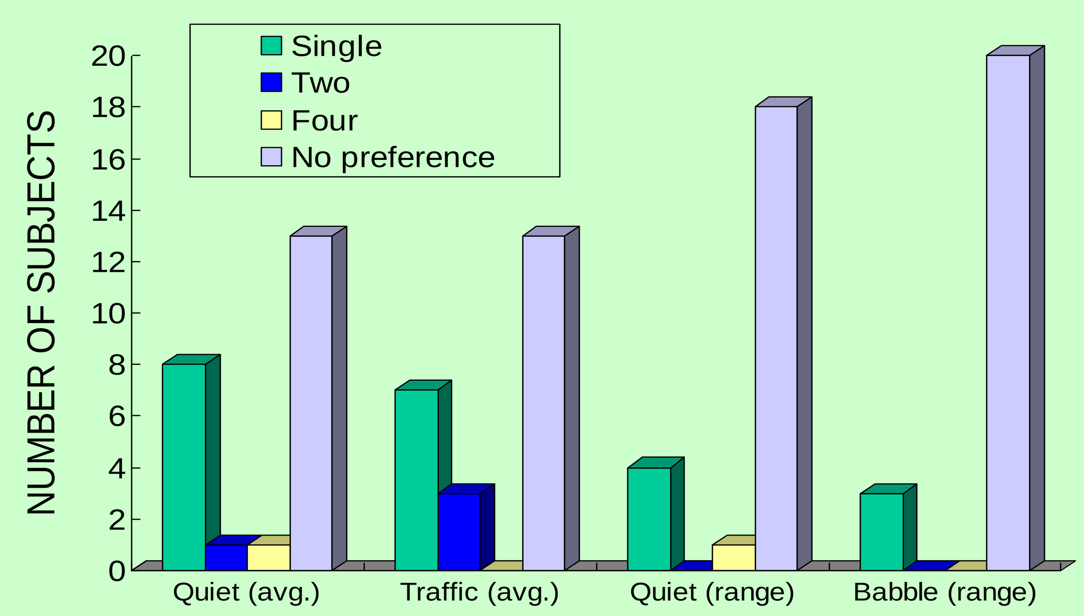
RESULTS 2 (How Many Channels?)

Paired Comparison



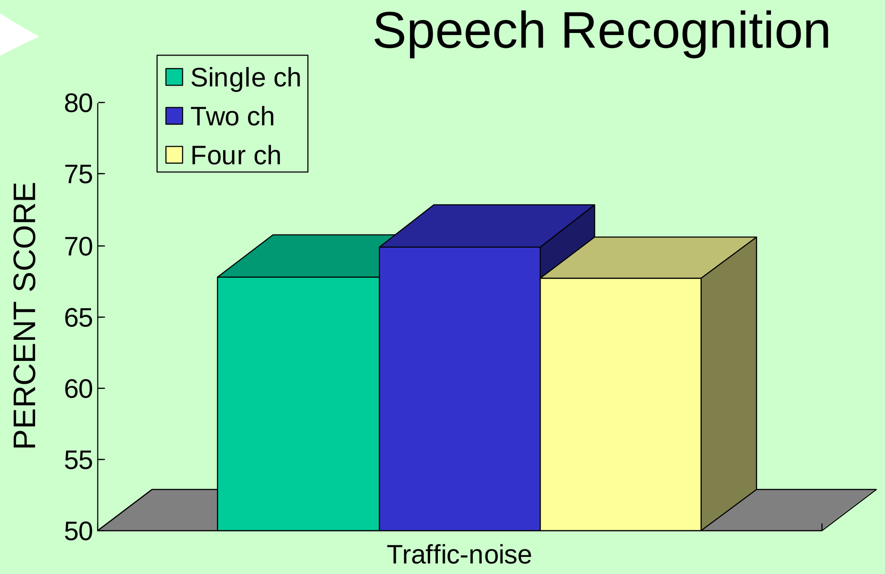
Average percentage preference obtained for each scheme in each of four listening conditions. An asterisk indicates that the difference between scores is significant.

Paired Comparison



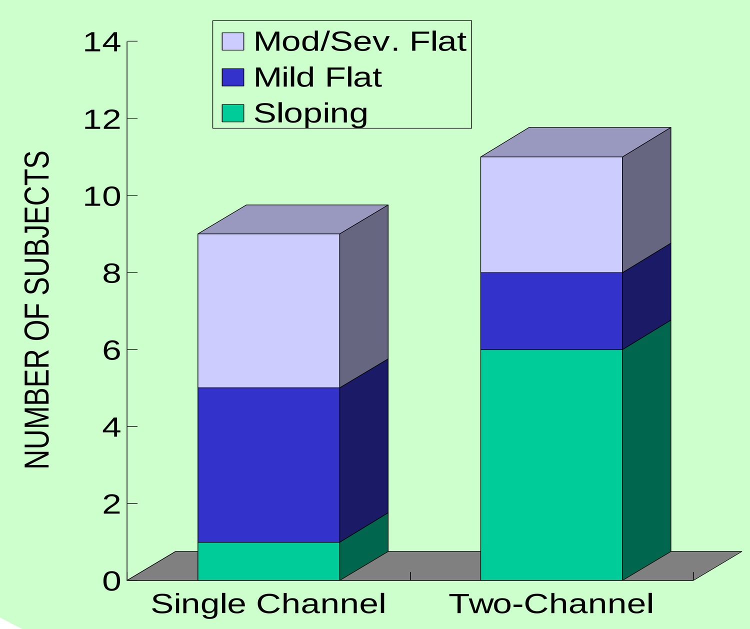
The number of subjects who showed a significant preference for one scheme over the others in each of the four listening conditions. Most subjects showed no preference for either scheme. The single channel scheme was preferred more often than the two- and four-channel schemes.

Speech Recognition



Average percentage score obtained by each scheme in traffic-noise. The difference in score is not significant.

Field Test



The number of subjects who reported a preference for either scheme after the field test. One subject could not distinguish between the two schemes, and three subjects withdrew from the test. Of the seven subjects with steeply sloping losses, who completed the field test, all but one selected the two-channel scheme.

CONCLUSION 2

The paired comparison test showed an overall small preference for single channel compression whereas the field test revealed a preference for two-channel compression over single-channel compression by people with steeply sloping losses. We recommend that people with sloping losses are fitted with at least two channels when using NAL-NL1 . For people with flat losses the number of channels is probably unimportant.

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