Apparent effects of the use of digital hearing aid "CLAIDHA" on several hearing functions of impaired listeners

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Abstract: The apparent effects of compression types of amplification on patients with sensorineural hearing loss were examined, especially the effects on the masking function and the intensity discriminability. The results indicate that the compression often sharpens the masking pattern as compared with simple linear amplification; i.e., it was possible to improve the audibility of a signal under masking conditions. As for intensity discriminability, at compression ratios less than or equal to two, the IDU (intensity difference limens) were moderate and slightly decreased as SPL increased, while at ratios of four, the IDUs became much larger.

INTRODUCTION

People with hearing loss experience a new world of sound due to amplification by using hearing aids. In the present study, the apparent changes of hearing characteristics caused by compression amplification were investigated using a digital hearing aid system CLAfDHA, which employs frequency-dependent amplitude compression based on the de-recruitment of narrow band loudness (1, 2). In EXPERIMENT I, the masking pattern under the narrow band noise (NBN) masker was measured and compared between CLAfDHA and linear amplification. In EXPERIMENT II, the apparent intensity difference limen (IDL) was examined with various compression ratios using the CLAfDHA system.

EXPERIMENT I

Subjects and Methods. Five subjects (four males and one female, with a mean age of 62 years), all of whom suffered from sensorineural hearing loss, participated in EXPERIMENT I in which the masking patterns with the use of an aid under various compression ratios were observed. The frequency response of the digital hearing aid (CLAIDHA) remained flat in all frequency regions; the gain character (input-output function) at the input level of 60 dB SPL was stayed at the same level and only the compression ratio was changed.

One-sixth octave band noise centered at 1 kHz and tone bursts in several frequencies were used as the masker and signal, respectively. The noise and signals were electrically mixed and fed into a digital hearing aid (CLAIDHA). Thresholds for the signals under the masker set at 60 dB SPL were then measured.

Results. The apparent masked thresholds for all the cases showed that the spread of masking effects towards the upper frequency region was smaller with the CLAfDHA amplification than with the linear amplification. To quantize the effect, the differences of the masked thresholds between the condition with amplification at each compression ratio and that with no amplification (the relative masked threshold) were plotted as a function of the compression ratio in FIGURE 1 for the five subjects at a 2 kHz signal. The relative masked threshold decreases as the compression ratio increases.

EXPERIMENT II

Subjects and Methods. Ten ears of eight subjects (six males and two female, with a mean age of 58.6 years), all of whom had hearing loss, were examined. The IDUs with the use of an aid under various compression ratios were measured by a sequential procedure with randomization (3). A pair of tone bursts (500 ms with rise and
fall times of 30 ms) with an interval of 550 ms were generated (TDT WG2), attenuated (TDT PA4), and electrically fed into a digital hearing aid. The task was to judge which stimulus in a pair was more intense. After 50 pairs of stimuli were presented, IDL was calculated by use of the maximum likelihood estimation to track the point on the psychometric function corresponding to a correctness level of 75%.

Results. For six ears of the ten subjects, the IDLs were measured at the levels of the standard tone levels from 50 to 80 dB SPL in 10 dB steps. The IDLs plotted as a function of the standard level indicated that, at the compression ratios less than or equal to two, the IDLs were moderate and improved (decreased) as the SPL increased and could be given an approximately straight line as a function of SPL (like 'near miss' to Weber's law (4)). At the ratio of four, the IDLs became much larger.

For each of the ten ears, the mean IDLs of repeated trials at 60 dB SPL were plotted as a function of the compression ratio (FIGURE 2). The mean IDLs increased as the compression ratio increased. Analysis of variance (ANOVA) showed that subject \([p < 0.0001]\) and compression ratio \([p < 0.0001]\) were significant as well as the interaction between compression ratio and subject \([p < 0.0001]\).

CONCLUSION

Apparent effects of compression on both the masked threshold and the IDL were examined using a digital hearing aid. The apparent masker thresholds were found to improve as the compression ratio increased and the IDLs increased as the compression ratio increased.

ACKNOWLEDGEMENTS

This work was supported by grants from Funds for Comprehensive Research on Aging and Health, 96B4101 and from the Ministry of Education, Science and Culture (Grant-in-aid for Scientific Research 06557089).

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