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SYLLABLE PERCEPTION IN THE PRESENCE OF BACKGROUND NOISE BY NORMAL AND HEARING IMPAIRED LISTENERS

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1. INTRODUCTION

Speech perception is known to be affected by the presence of background noise [1, 2]. Speech syllables in continuous noise are easier to recognise than if the noise is co-gated (i.e. turned on at the beginning of the sound and off at the end) [3]. The intelligibility of the syllables increases as the duration of the noise preceding the syllables is made longer [4]. The effect of the noise is also dependent on its frequency and bandwidth with normal hearing subjects [5].

The previous work was carried out with university students and staff at the Keele University acting as subjects. These experiments [5] have been extended to include subjects with a hearing loss as well as normal hearing subjects. Both sensorineural (SNHL) and conductive hearing loss (CondHL) subjects were selected from a routine ENT outpatient clinic. The original experiments using Keele University subjects used a signal to noise ratio of 0dB; in the experiments with the general population subjects the signal to noise ratio was varied. The aims of the experiments were to see if the same effect as seen with the original experiments (Table 1) could be replicated in the general population and to see if the effect was maintained in those with a SNHL or CondHL.

2. METHOD

All subjects underwent a pre-test audiogram including bone conduction. Normal hearing subjects (average audiogram < 20dB), SNHL subjects and CondHL subjects were chosen from a routine ENT outpatient clinic. The average hearing loss was mild/moderate (< 50dB). All test sounds were presented at a supra-threshold level. The test sounds were the voiced plosives /b, d, g/ in combination with the vowels /3, a, e, i, o, u) spoken by a male English speaker, but truncated to 100ms in duration. They were digitised with a sampling rate of 11,025 Hz. This sound was mixed with white noise which had been passed through a 1-2 kHz band pass FIR filter. The duration of the noise was varied (co-gated, 100ms preceding and 800ms preceding). Each of the 18 test sounds was presented five times randomly to the subject's test ear. The subject was asked to identify the initial consonant of each syllable they heard and to press B, D or G on a computer keyboard as appropriate.

3. RESULTS

The initial experiments repeated the original experiments (see Table 1) carried out at the Keele University but in the Ear, Nose and Throat outpatient setting of the hospital. The volume of presentation was 80 dB (A) and the signal to noise ratio (SNR) was 0 dB (Table 2). The results

were found to be only at chance level and so the SNR was raised to 12 dB (Table 3). However the results were again at chance level and so the SNR was raised to 36 SNR (Table 4). In all these experiments the volume of presentation was 80 dB. At this level (36 SNR, Volume of presentation 80 dB), the effect was observed in the normal hearing subjects, but not in either the SNHL subjects or the CondHL subjects. The volume of presentation was the reduced to 66 dB but the 36 dB SNR was maintained (Table 5). Again the effect was not observed in the SNHL subjects. Although the effect was seen in the normal hearing subjects, it was much reduced. At present insufficient CondHL subjects have been tested at this level (36 dB SNR and volume of presentation 66 dB).

Table 1

Original experiments (SNR 0 dB/Volume 70 dB)

n = 9	0 ms	100 ms	800 ms
% Correct (mean/SD)	60.1 ± 7.9	66.2 ± 11.8	75.8 ± 8.4

Table 2

New experiments at ENT outpatients (SNR 0 dB/Volume 80 dB)

	0 ms	100 ms	800 ms
Normal (n = 6) % correct (mean/SD)	32.0 ± 8.2	36.25 ± 6.8	44.0 ± 9.0
SNHL (n = 4) % correct (mean/SD)	38.0 ± 5.7	39.4 ± 7.9	35.5 ± 8.9
CondHL (n = 7) % correct (mean/SD)	34.1 ± 6.8	33.5 ± 6.5	42.0 ± 6.5

Table 3

New Experiments at ENT outpatients (SNR 12 dB/Volume 80 dB)

	0 ms	100 ms	800 ms
Normal (n = 8) % correct (mean/SD)	43.2 ± 7.2	43.3 ± 8.8	44.9 ± 5.1
SNHL (n = 11) % correct (mean/SD)	41.4 ± 6.2	44.8 ± 8.0	45.1 ± 10.7

Table 4

New experiments at ENT outpatients (SNR 36 dB/Volume 80 dB)

	0 ms	100 ms	800 ms
Normal (n = 16) % correct (Mean/SD)	62.1 ± 12.1	66.7 ± 11.0	72.1 ± 9.0
SNHL (n = 6) % correct (Mean/SD)	68.1 ± 5.4	63.0 ± 11.4	71.6 ± 8.8
CondHL (n = 7) % correct (Mean/SD)	83.7 ± 7.5	81.1 ± 8.5	87.0 ± 4.4

Table 5

New experiments at ENT outpatients (SNR 36 dB/Volume 66 dB)

	0 ms	100 ms	800 ms
Normal (n = 9) % correct (Mean/SD)	76.3 ± 7.8	78.6 ± 8.8	79.9 ± 8.6
SNHL (n = 7) % correct (Mean/SD)	77.8 ± 7.7	74.6 ± 13.5	72.5 ± 7.5
CondHL (n = 1) % correct	92.2	88.9	92.2

4. DISCUSSION

When a signal to noise ratio is chosen which gives a correct response rate of approximately 60%, the improvement in intelligibility with increasing preceding noise is seen in normal hearing subjects (Table 4). The conductive hearing loss subjects do not show the same effect but this may be because the test situation for the CondHL subjects is actually more like the test situation in Table 5 for normal subjects i.e. where no effect is seen. The SNHL subjects do not show the effect, but this may be due to the reduced dynamic range that is seen in these subjects.

It is unclear why the general population subjects perform relatively less well (Tables 2-4) compared to the university population previously tested (Table 1). Although the test noises were chosen so that basic intelligence would not affect the results, but it may be that the noises are too difficult to recognise.

When the volume of presentation was reduced to 66 dB from 80 dB, the intelligibility of all the sounds were improved (approximately 60% to 70%). However the effect of the duration of the noise is reduced. This may be due to there not being enough noise to cause the effect.

5. FURTHER EXPERIMENTS

The next experiments will look at the effect of increasing the volume of presentation (to 90 dB) with the CondHL subjects. At this level, approximately equivalent to 70 dB with normal hearing listeners, there may be an effect of increasing the duration of the noise on the intelligibility of the test sounds.

Further experiments will be to replace the test sounds with digits, which are more intelligible at lower SNRs [6], to see if the effect could be seen at lower SNRs.

6. CONCLUSIONS

Experiments have been carried out to compare the effects of preceding noise on the intelligibility of voiced plosives in isolated syllables with hearing impaired and normal listeners. It was found that for normal listeners intelligibility increases as the duration of the preceding is lengthened provided the SNR and presentation level are carefully chosen. For listeners with conductive or sensorineural hearing losses the appropriate SNR and presentation level are difficult, and perhaps impossible, to achieve.

7. REFERENCES

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