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WIND NOISE IN HEARING AIDS

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INTRODUCTION

When a head worn hearing aid is used outdoors, users often find wind generated noise to be "so intolerable as to prefer not to use the aid" (1) The noise is generated by turbulent airflow past the head. It has been shown (2, 3) that the noise detected, for a given wind incidence condition, varies with microphone location on the aid. The present work measured the difference between the wind noise detected by the eardrum and that at five points around the pinna. The outer ear test points were chosen to represent possible hearing aid microphone locations.

The difference between the noise level at the eardrum and at each testpoint allowed a corresponding change of signal to noise ratio to be defined, incurred when an aid is used in a windy environment. These wind induced differences in signal to noise ratio at the test position and eardrum represent one component of the hearing aid users wind noise problem.

Since the nature of a turbulent flow may be loosely described in terms of the incident windspeed and the typical dimension of the obstacle from which a given stream of vorticity was shed (after Strouhal), wind noise is seen to be dependant upon both wind speed and angle of incidence. The wind induced change of signal to noise ratio was, therefore, measured for each test point at four windspeeds and two angles of incidence.

EXPERIMENTAL PROCEDURE

Since the wind noise at a given test position is strongly dependant upon the shape of the subject head investigated ((4) noted changes in 1/3 octave band levels for given wind conditions, in the conchae of human subjects of 15 dB), the tests were made around an unclothed anthropometric manikin. The KEMAR manikin was chosen, enabling the eardrum wind noise data to be collected by a microphone in a Zwislocki ear simulator, located in the manikin's ear.

The five outer ear test locations, at which a probe microphone was used to detect the total fluctuating pressure, were as defined in the figure 1. Position 1 was chosen to represent an "in the ear" aid's microphone location, whilst 2 - 5 corresponded to "behind the ear" aids. The body of the probe microphone was located downstream of the ear so as to cause minimum disruption of the flow around the ear.

The experiment required the provision of steady repeatable incident windspeeds. It was therefore necessary to conduct the tests in a wind tunnel. Incident windspeeds of 2.5, 5, 7.5 and 10 m/s were chosen to cover the range typically

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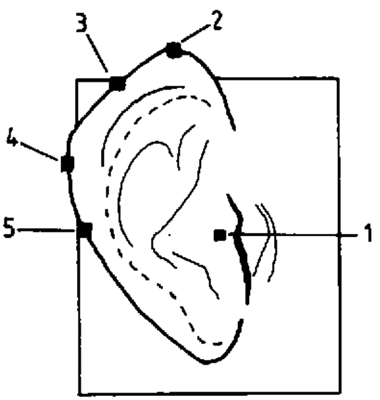
experienced at ground level. Two angles of wind incidence, in the horizontal plane, were investigated. The two incidence angles had been previously shown (3) to correspond to "bad" ($\alpha = 45^{0}$) and "good" ($\alpha = 270^{0}$) cases for wind generated noise.

fig.1 TEST POSITIONS.



For each wind condition/test point 30 second samples of the signal from the probe microphone and from the "eardrum" microphone were simultaneously recorded onto magnetic tape. The data was subsequently analysed into power spectra which were integrated into 1/3 octave bands, centre frequencies 100 - 8000 Hz, for ease of manipulation.

RESULTS AND DISCUSSION

The difference, for each wind condition, between the wind noise at a given test position and that at the eardrum, "ΔN", was obtained by subtracting the two relevant 1/3 octave noise spectral values. The influence of these changes in background noise can be conveniently expressed as a corresponding change in signal to noise ratio, thus it was necessary to measure the change in signal between each of the test points and the eardrum. The change in signal, measured for a source 1.4 m in front of KEMAR is almost entirely due to the ear canal acoustic transfer function, which has been well documented.

Figures 2 and 3 show the overall wind induced change in signal to noise ratio, w.r.t. the unaided ear, for positions 1 and 5.

In all test conditions investigated a high degradation of signal to noise ratio was noted. No test returned an overall degradation of less than -10 dB which is sufficient to cause a devastating shift in the aid's utility. The findings of earlier work regarding angle of wind incidence were supported in that all results for $\alpha = 45^{0}$ were significantly worse than those at $\alpha = 270^{0}$.

Although differences in subject head geometry make it dangerous to attempt to infer optimum microphone locations (from the viewpoint of wind noise), it is considered to be worth noting that position 1, in the concha 3 mm behind the tip of the tragus, returned the lowest wind induced degradation of signal to noise ratio whilst position 5 showed the poorest performance.

The measures of signal to noise degradation presented are subject to the following assumptions:

(i) that the hearing aid microphone responds to the total pressure fluctuation imposed upon it (as opposed to simply the acoustic component)

(ii) that the total pressure transfer function from test point to eardrum for the Zwislocki/KEMAR system is an acceptable approximation to that of the real ear.

CONCLUDING REMARKS

The wind induced changes of signal to noise ratio reported are of sufficiently high values to explain the inadequacy of hearing aids when worn outdoors. In addition flow instabilities over the aid will also introduce further noise, thus the "ΔS/N" measured here only accounts for part of the wind noise problem.

REFERENCES

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figs. 2,3 WIND INDUCED CHANGE of SIGNAL to NOISE RATIO, "ΔS/N". [+——+ dB(lin.) o- - - -o dB(A)]