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TINNITUS AND NOISE INDUCED TINNITUS

by

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The purposesof this paper are (1) to comment upon certain aspects of tinnitus and (2) to mention methods and results from some recent research into noise induced short duration tinnitus.

It is widely accepted that tinnitus is an almost universal symptom of acute acoustic trauma; evidence from a number of researches supports this belief. We are much less certain to what extent tinnitus occurs with chronic acoustic trauma. The evidence from research is conflicting as the following four examples show. Barr (1886) found that only 8 from a sample of 100 boilermakers experienced tinnitus; a further 34 had noises in their ears at certain times only. More recently Venters (1953) found virtually no relationship between the occurrence of tinnitus and acoustic hazard; over a period of 20 years a boiler works produced only one case that came to his notice. Goldner (1957), on the other hand, noted that among shipyard and other noise-exposed workers tinnitus was one of the commonest complaints and seemed more disabling than the deafness. Atherley (1967), in a study of foundrymen who used pneumatic hammers, found that 33 out of 55 men experienced tinnitus.

It is obvious from Goodhills list (1950) of aetological factors that tinnitus can be a symptom of almost all otological disorders. Indeed, Fowler (1944) found it present in 86% of 2000 consecutive patients. Hinchcliffe's findings (1961) are particularly interesting because he studied two random samples from the rural population-at-large in the U.K. He found that in the age group 18-24 yrs, 21% of individuals had noticed noises in their ears or heads: in the 65-74 yrs group the figure was 37%. This, together with the evidence of Heller and Bergman (1953) that tinnitus occurs in people with normal hearing, shows that noises in the ears or head is a common phenomenon, with or without disorder of hearing and perhaps even without prior noise exposure. It is clear from Graham's review (1965) that although tinnitus is said to be closely associated with deafness the degree of the deafness may sometimes be very slight.

Overall there is disparity in the evidence; undoubtedly some stems from the lack of a criterion of tinnitus and its effects on individuals. Until we have a reliable description of tinnitus associated with various states of hearing it will not be possible to decide whether a history of tinnitus in a noise exposed workman is a matter of any importance. It seems that in most instances tinnitus is a mild symptom no matter what its cause. There is some evidence, however, that a minority find the condition troublesome. One possible factor has been suggested by Dawson (1969) who

regards some instances of tinnitus following otological surgery as 'auditory causalgia'. This condition might also be a sequel to severe acoustic trauma. A further factor has been identified by the two Fowlers (1955) who emphasize the importance of emotional disturbance in determining the response of an individual to this particular aural symptom.

Acute acoustic trauma induced in subjects with normal hearing was used as the basis of the study. Noise induced short duration tinnitus (NIST) and the associated T.T.S. were investigated using a variety of inducing stimuli.

The Experiment

The subjects who were all aged between 17 and 35 were psychology undergraduates and members of the academic and technical staff of two universities. All had hearing thresholds that were within 30 dB of British Standard Zero at all frequencies.

Air conduction thresholds of both ears for all subjects were measured using an interrupted pure tone sweep frequency audiometer. The stimuli used for inducing the NIST were 1/3 octave bands of white noise centred at 1KHz, 2KHz, 3KHz, 4KHz and 6KHz and pure tones of the same frequencies. In the case of 1/3 octave noise the level was set to 110dB SPL and for the pure tones it was set at 120 dB SPL. The stimulus was delivered by earphone to one ear for five minutes. Following the exposure a comparison tone was delivered to the non stimulated ear and adjusted for both frequency and level until the subject reported that it matched his NIST. The frequency of this comparison tone was taken as the pitch of the NIST and its sensation level in the non stimulated ear taken as the loudness of the NIST. A further determination of threshold was then made in the stimulated ear.

Results

1) The occurrence of NIST - Of these subjects who experienced a TTS large enough to measure 90 per cent of them reported tinnitus.

2) Relationship between stimulus frequency and frequency of maximum threshold shift - As was to be expected, as the frequency of the stimulus increased so did the frequency of the maximum threshold shift (MTS). For both narrow band noise and pure tone stimuli the change in frequency of MTS with change of frequency of stimulus was highly significant ($P<0.001$)

3) Relationship between stimulus frequency and pitch of NIST - It was found that the pitch of NIST also increased as the stimulus frequency increased and again for both narrow band noise and pure tone stimuli the relationship was highly significant ($P<0.001$). Most subjects had no difficulty in assigning a pitch to their NIST and in most cases they reported that it had a definite tonal quality

4) Relationship between frequency of MTS and pitch of NIST - The relationship between MTS and NIST was investigated separately for the narrow band and the pure tone stimuli. The pitch of the NIST was always lower than the frequency of MTS. A regression equation for the narrow band data is $y = 0.8x + 0.3$ where y represents the pitch of NIST in KHz and x is the frequency of MTS in KHz. The correlation coefficient between pitch of NIST and frequency of MTS is +0.82.

As there was reason to believe from some results of Loeb and Smith (1967) that the data from the pure tone stimuli would differ

from the narrow band data it was examined separately. However, contrary to the findings of Loeb and Smith, it was found that the two sets of data did not differ significantly.

5) Loudness of NIST - The loudness of NIST was calculated as the sensation level of the comparison tone in the non stimulated ear. The mean sensation level of the NIST was 10dB and was independent of the degree of TTS. There was no systematic variation for different stimuli and in no case was the level greater than 25dB. This is in agreement with the findings of Reed (1960) who reported that 70% of subjects with various types of lesion matched their tinnitus to levels below 10 dB SL.

Discussion

Considering the difficulty of obtaining data in this type of psycho-acoustic experiment the evidence suggests that the NIST and TTS have a common origin. It is apparent that the NIST is always lower in pitch than the MTS and that this difference increases as the frequency of the stimulating signal increases. This observation is not inconsistent with the belief that NIST and TTS are closely related. If the difference in frequency between NIST and MTS is expressed in terms of the inferred distance along the basilar membrane we find the difference represents an approximately constant distance (about 1.3mm) irrespective of stimulus frequency.

None of our subjects complained of the NIST being particularly severe and in most instances it disappeared within five minutes of the removal of the stimulus. In a few cases it lasted several hours and on two occassions into the following day. The initial sensation level of the NIST did not determine its duration. It is not clear why there is this wide variation between individuals in the duration of NIST. One factor may be the nature of the stimulating signal, for example when it was a pure tone the level had to be increased to 120dB SPL in order to elicit tinnitus which lasts for a sufficient length of time to obtain a pitch match.

We see as an objective for research, the establishment of a criterion of tinnitus whereby the degree to which tinnitus is an additional disabling factor in occupational hearing loss may be assessed.

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