Hearing Loss in Rock-and-Roll Musicians

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Recent reports in both scientific and popular literature have suggested that rock-and-roll music may be hazardous to hearing. Most of the reports have agreed that prolonged exposure to the music is potentially hazardous. Differences of opinion are apparent, however, concerning the magnitude of expected loss, the likelihood that the damage might be permanent rather than temporary, and the validity of predicting potential hazard from measures of sound level.

This paper examines some of these issues, and reports measures from 10 rock-and-roll bands involving 54 musicians.

Method

Measures of sound level were made during a single performance by each of 10 rock-and-roll bands. All measures were made with a sound level meter (Bruel and Kjaer, 2,203), octave filter set (Bruel and Kjaer, 1,613), and calibrated condenser microphone (Bruel and Kjaer, 4,131).

Sound levels were checked at several locations on the bandstand and in the general dancing area. These multiple locations allowed evaluation of the exposure to both the musicians and to those persons attending the dance.

At each location, measures were made of overall sound pressure level (dB re 2 x 10^{-4} μ bar), A-weighted sound level (dBA), and the sound pressure level in octave bands with center frequencies ranging from 31.7 to 8000 Hz in octave intervals. Each of the three measures was made a minimum of five times during the evening performance.

In addition to an evaluation of noise levels, measures of temporary threshold shift* (TTS) were made on 25 of the 54 musicians. Pre-exposure audiograms were obtained about one to two hours before an evening performance. Postexposure audiograms were obtained as quickly as possible after conclusion of the dance, usually with a delay of about 20 to 40 minutes. All audiograms were made in the same facility.

Results

What were the magnitudes of sound levels? Overall sound pressure levels, on stage, for the 10 bands ranged from 105 to 120 dB SPL. Moving the meter to various locations around the stage resulted in no more than minor variations in level, thereby suggesting the presence of a rather uniform exposure; dBA levels generally ranged from about 90 to 110. Measures taken in the dancing area were about 10 dB lower than those observed on stage.

**A temporary elevation in hearing threshold level following exposure.*

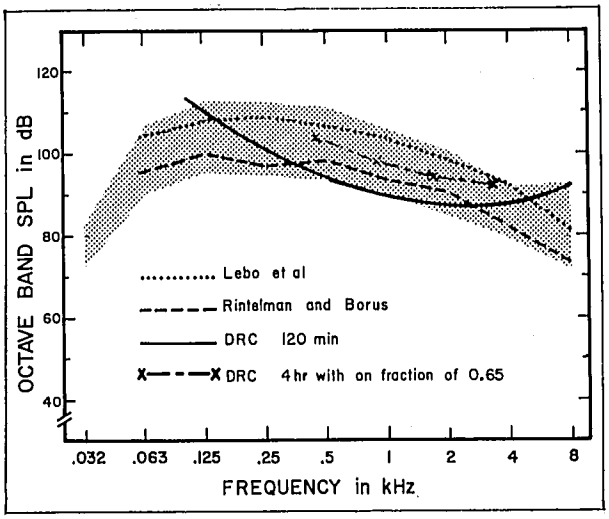

Fig. 1. Average spectra for ten rock-and-roll bands.

The results of the octave band analysis for the bands are shown in Fig. 1. Sound pressure level in dB is plotted as a function of the octave band center frequency in kHz.

The shaded area of Fig. 1 shows the range of noise ("music") spectra, and represents the average of frequent peaks observed on the meter. Thus, the upper border of the shaded area refers to the average level for the loudest of the bands, and the lower border provides similar information for the least loud bands. These spectra compare quite favorably with the average spectra reported by Lebo et al.[1] (dotted line) for six bands and by Rintlemann and Borus[2] (broken line) for six bands.

It is apparent that the energy is spread over a rather wide range. The noise levels exceeded a sound pressure level of 90 to 95 dB from an octave band centered at 63 Hz to an octave band centered at 2000 Hz. Above 2000 Hz, the levels slowly diminish with increasing frequency.

Are these noise levels hazardous to hearing? There is no way to provide a simple answer to this question. As a starting point, any noise band exceeding 130 dB SPL can be considered hazardous to hearing. [3] At this intensity, the duration of the exposure and the spectral composition can essentially be ignored. None of the measures on the 10 rock-and-roll bands approached this level. Thus, it is necessary to interpret the spectra in Fig. 1 relative to the duration of exposure commonly experienced by band members.

Most sessions were somewhat less than four hours, and actual music time generally was only 120 to 150 minutes interspersed throughout the four-hour block. The solid line in Fig. 1 illustrates the damage risk criterion (DRC) proposed by Working Group 46 of the Committee on Hearing, Bioacoustics, and Biomechanics (CHABA).[3] This curve indicates the maximum amount of a steady, uninterrupted noise to which the human ear should be exposed daily for two hours without risking permanent damage to hearing.

Below 125 Hz, most of the shaded area lies below the DRC. Within the frequency range 125 to 4000 Hz, most bands exceeded the DRC. More specifically, from 500 to 2000 Hz, all the shaded area falls above the 120 minute DRC. These comparisons suggest that the music could be potentially hazardous, but such a conclusion must be tempered by a realization that the music is not the steady, uninterrupted noise to which the DRC refers. The exposure is intermittent, not continuous, and in fact does not even remain continuously at the peak levels of 105 to 120 dB SPL.

Fortunately, the CHABA DRC do predict levels, for octave bands between 300 and 4800 Hz, that should be tolerable under conditions of intermittent exposure. In the present case, the worst pattern of exposure involved a total of 150 minutes of high-intensity sound during a period of four hours, so that the "on-fraction" was at most 0.65. If the CHABA DRC for noise with this intermittency factor are consulted, the tolerable limits for four-hour exposures to the octave bands centered at 425, 850, 1700, and 3400 Hz turn out to be 103, 96, 93, and 90 dB, respectively. These values, indicated in Fig. 1 by crosses, run right down the middle of the measured range of levels. Thus, the intermittency of the exposure is just sufficient to reduce the average hazard to that judged acceptable by the CHABA DRC, so that some bands exceed the limit slightly; others remain below it. "Acceptable risk," as used in the CHABA DRC, has been estimated to be a 10 percent probability that a person exposed daily, five days a week for 20 years, will develop a handicapping hearing loss.[4]

It must be concluded from these results, therefore, that the noise levels are sufficiently high to advise the prudent man to restrict the amount of this kind of exposure, but that only the most sensitive ears should be in any real danger, and then only after many years of exposure.

Was there evidence of a temporary threshold shift following exposure? Fig. 2 plots the average shift in threshold for 25 musicians. TTS in dB is plotted as a function of test frequency. The vertical bars represent the standard deviation in decibels. On the average, a slight shift of about 7 to 8 dB occurred at 4000 and 6000 Hz. Shifts of this magnitude certainly are not alarming since it is generally considered that shifts of less than 20 dB at these frequencies are within a "low hazard" region. The criterion of 20 dB, however, applies only to the situation when postexposure measures are made two minutes after the ear has been removed from the noise, TTS_2. In other words, shifts greater than 7 to 8 dB could have occurred and then recovered to this low level during the 20 to 40 minute period before post-exposure audiograms were obtained.

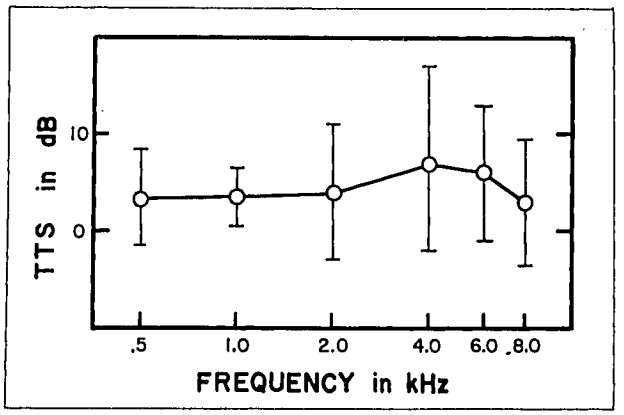

Fig. 2. Average threshold shift for 25 musicians following exposure to rock-and-roll music. The standard deviation in decibels is shown by the vertical lines.

Although extrapolation is always risky in cases such as these, the magnitude of TTS that might have existed at two minutes can be estimated from the measures made at an average of 30 minutes. The general recovery curves of Ward et al. indicate that an average TTS_{30} of 8 dB would correspond to a TTS_2 of 16dB[5]. In other words, the extrapolated TTS_2 does approach a criterion of 20 dB for potential hazard.

Table I shows a distribution of TTS_{30} observed for six different frequencies. The entries are the number of musicians who evidenced the magnitude of TTS shown at the left for the test frequencies shown at the top. Twelve of the 25 listeners (about half) showed a TTS greater than 10 dB at one frequency or another. As expected, the greater instance of TTS occured at 4 and 6 kHz.

How, then, are we to interpret these results? In effect, at what point is TTS sufficiently large to signal hazard? One problem concerns how to handle a TTS of less than 5 dB. We cannot be certain, for example, whether a TTS_{30} of less than 5 dB was *really* about 10 dB at two minutes and recovered, or whether in fact there was no shift in excess of the limits of error in audiometric testing. In any event, such small values of TTS_{30} could hardly be dangerous. We are more confident, however, of what TTS_2 must have been when TTS_{30} was 10 dB or greater. In these individuals, we can say that TTS_2 was at least as large as that measured at 30 minutes, and possible quite a bit greater. If we attempt to estimate TTS_2 for those individuals showing a TTS_{30} of about 20 dB, the shift could have been as large as 40 dB. Shifts of this magnitude may well be hazardous when repeated daily for many years.

Thus, by this analysis, about one-half of the musicians demonstrated a temporary shift in threshold that could have reached a TTS_2 criterion of 20 dB. Since the CHABA DRC admittedly try to keep the average TTS_2 to this value, the TTS results are in good agreement with the conclusion reached by considering only the nature of the noise exposure pattern and levels: namely, that the hazard is precisely borderline.

TABLE I

INCIDENCE OF TEMPORARY THRESHOLD SHIFT, IN DECIBELS, FOR 25 MUSICIANS AT FIVE TEST FREQUENCIES

	Frequency in Hertz				
TTS in dB	500	1000	2000	4000	6000
⩽0	7	4	8	2	5
1 - 5	11	15	7	11	8
6 - 10	6	6	7	5	7
11 - 15	–	–	2	5	2
16 - 20	1	–	–	2	2
21 - 25	–	–	1	–	1

Was there evidence of a permanent hearing loss? Six of the 25 musicians had what appeared to be a permanent hearing loss (HL greater than 20 dB re ISO). Rintelmann and Borus reported that 2 of the 42 musicians that they surveyed had an apparent permanent loss.[2] Obviously, however, rock-and-roll music cannot be implicated as the sole cause in the absence of other evidence. In each instance, those musicians who evidenced a substantial hearing loss also had engaged repeatedly in hunting, trap shooting, or had served in the artillery of the armed services.

Again, then, we see that the predictions of hazard implied by the TTS and sound level measurements are confirmed: the exposures are borderline.

Summary

The noise level of 10 individual rock-and-roll bands, involving 54 musicians, ranged from 105 to 120 dB SPL (90 to 110 dBA). Audiometric studies were completed on 25 of the musicians. Six demonstrated a possibly dangerous temporary hearing loss following exposure. In addition, six more had what appeared to be a permanent loss of hearing.

All results imply that the typical exposure of a musician, if repeated daily for many years, is potentially hazardous. Unfortunately, the evidence on which the predicted hazard is based for intermittent noises such as those involved in this study is scant. Until more evidence becomes available, it is unwise to say that such music *is* hazardous and will cause a hearing loss. Nevertheless, it is equally apparent that continued and prolonged exposure to noises of this level will increase the probability of damage. Prudence would dictate the use by musicians of a satisfactory earplug to minimize the likelihood that handicapping loss of hearing will result from such exposures.

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Who Owns the Air?

The basic difficulty with a lawsuit against an air or water pollutor, or a proposed new airport or housing development or ski resort in the midst of a wilderness area, is that such a suit does not fit the accustomed court idea of what a lawsuit should be. Private law in this country, and earlier in England, developed its manifold rules and procedures in cases and controversies where one side had allegedly harmed another. This harm could be redressed by a judicial judgment ordering the defendant to pay a sum of money to the plaintiff. The concept of an injunction grew out of the basically private harm situation. The defendant here would be ordered to do something, or desist from doing something, but whatever he did would redound to the benefit of the plaintiff in a way that the mere payment of money could not. Again, injunctions tended to be private matters, such as ceasing to trespass upon the plaintiff's land or desisting from an unfair method of business competition.

Historically, individual plaintiffs have sued to redress private injuries. The law has known some exceptions, such as limited class actions to abate a public nuisance, or shareholders' derivative suits. But by and large public nuisances, or corporation frauds, have been the province of the attorney general suing in behalf of the public. Legislation making such activities criminal in itself takes effective control out of the hands of the public, since no private person can bring a criminal action against any defendant.

–From "Environmental Degradation and Legal Action" by Anthony A. D'Amato in Bulletin of the Atomic Scientists, *March 1970, p 24.*