AUDITORY FATIGUE: INFLUENCE OF MENTAL FACTORS

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Conflicting reports regarding the influence of mental tasks on auditory fatigue have recently appeared in the literature. In the present study, 10 male subjects were exposed to a 4000 cps fatigue tone at 40 dB SL for 3 min under conditions of mental arithmetic and reverie. Temporary threshold shifts, as indicated by comparing pre- and post-fatigue thresholds, were consistently greater when subjects worked mental arithmetic during exposure to the fatigue tone than when they engaged in reverie.

Wernick and Tobias[1] recently reported that the amount of temporary threshold shift (TTS) induced by a fatigue tone varied with instructions designed to influence the subject's level of mental activity. Shifts were greater for both low-level (40 dB SL) and high-level (90 dB SL) fatigue when subjects performed mental arithmetic than when they simply relaxed in a "reverie" state. Subsequent studies have failed to confirm this finding.[2-4] In two of these studies,[2,4] tasks different from those used by Wernick and Tobias were employed. Experience with the manipulation of sensory responses by instructions concerning mental activity indicates that all tasks are not equal in producing a given effect.[5,6] Consequently, the present authors replicated the low-level fatigue condition of the Wernick and Tobias study in order to explore the possibility that differences in task or procedure might account for the failure of the subsequent experiments to detect differences in fatigue as a function of mental activity during the fatigue period.

APPARATUS

Figure 1 shows a block diagram of the instrumentation which, as with Wernick and Tobias, comprised three basic parts: a fatigue channel, a test channel, and a light signal for the subject. The fatigue tone was generated by a Hewlett-Packard model 200 CD oscillator and led through a Hewlett-Packard model 350 B variable attenuator. The test tone, generated by a Hewlett-Packard model 201 C oscillator was led through a Grason - Stadler model 829S electronic switch, a Hewlett-Packard model 350 B variable attenuator, and a Grason-Stadler model E-3262A recording attenuator (attenuation rate — 4 dB per sec). Test tone, fatigue tone, or no tone (as selected by the experimenter) was transmitted to one ear by a set of Telephonics TDH-39 earphones with MX-41/AR cushions. The signal light in the subject room was controlled by the experimenter.

SUBJECTS

Subjects were 10 paid volunteers, experimentally naive males between the ages of 19 and 29 years. All had normal hearing. All subjects received fatigue stimulation under conditions of mental arithmetic (MA) and "reverie" (REV).

PROCEDURE

The procedure replicated exactly that of the low-level group of Wernick and Tobias, omitting the control conditions in which no fatigue stimulus was presented during the task. Half of the subjects received MA first and the remainder received REV first. The two trials

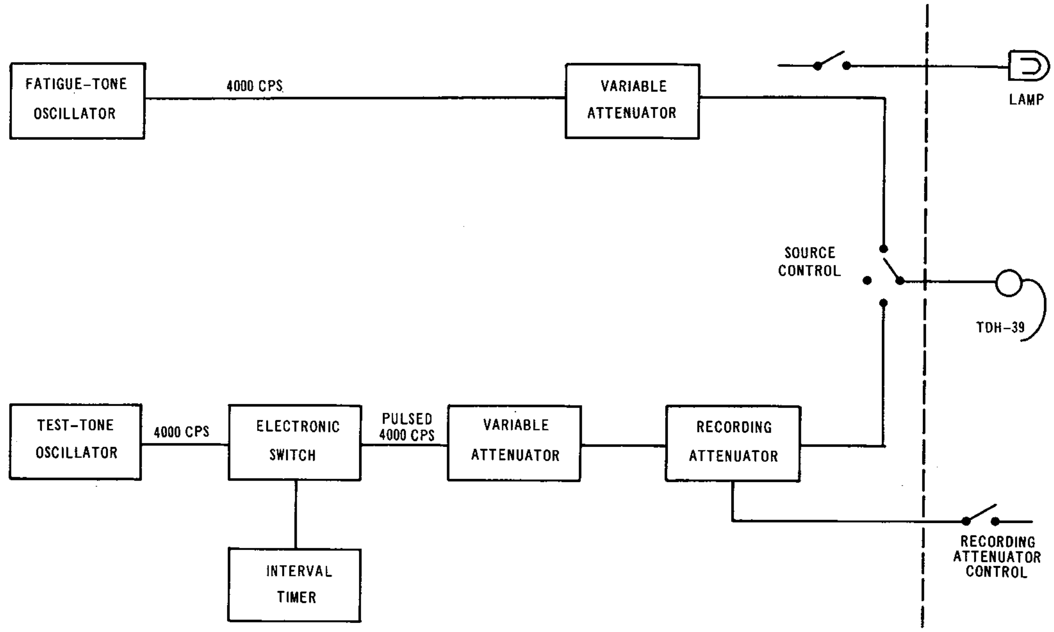

Figure 1. Block diagram of the apparatus.

were separated by 48 hours, and the first trial was preceded by several practice threshold determinations. A 3 min rest period followed a 2 min Bekesy-type threshold determination for the test tone, after which the fatiguing stimulus was presented for 3 min. A 3 min continuous threshold determination at the fatigue tone frequency was made immediately following the cessation of the fatigue tone.

The test tone was a 4000 cps pulsed tone (0.2 sec on, 0.2 sec off); the fatigue tone was a 4000 cps continuous tone presented at a sensation level of 40 dB.

The instructions given in the original study[1] were used here and comprised directions for activity during the fatigue stimulus. A subject was instructed either (1) to relax and follow no train of thought, or (2) to work a mental arithmetic problem involving continuous division with a constant divisor. A light in the subject-room provided the signal for the beginning of the fatigue period during which the subject performed as previously instructed. The experimenter turned off the light to signal the subject to start establishing his post-fatigue threshold.

RESULTS

Figure 2 shows the course of recovery from auditory fatigue for each of the two conditions. It is clear that exposure to the fatigue tone while the subjects were doing MA consistently produced greater TTS than exposure to the tone during REV. The mean TTS 10 sec after cessation of the fatigue tone was 6.25 dB (standard deviation = 3.14) for MA and 2.15 dB (standard deviation = 2.73) for REV, giving a difference of 4.10 dB favoring MA. A t test for correlated observations[7] conducted on the individual differences in TTS between MA and REV at the 10 sec point, yielded a t value of 6.16 with 9 degrees of freedom, significant at the .001 level. All of the subjects tested, including seven who did not participate in the formal experiment but only in pilot studies and such, showed a greater shift for the MA condition.

In addition to the difference in TTS between the two conditions, a longer recovery time for MA seems to be indicated by the curves of Figure 2.

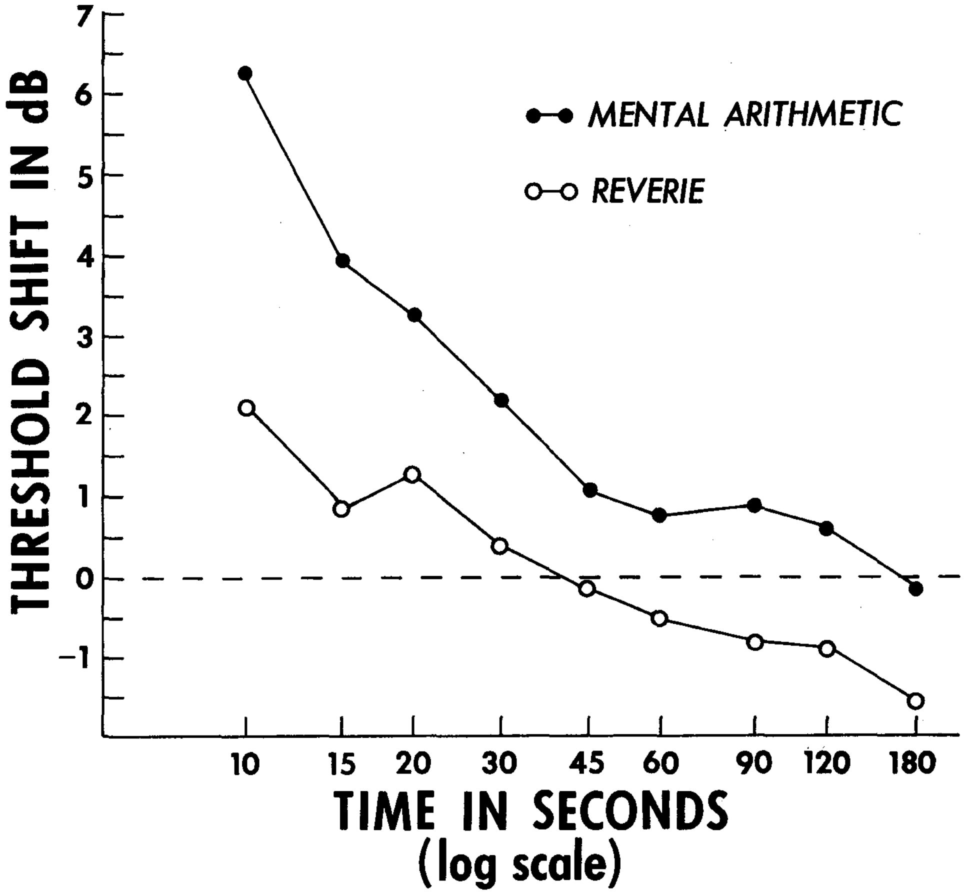

Figure 2. Mean temporary threshold shift for 10 subjects as a function of instructions regarding mental activity. Subjects were either in "reverie" or performing continuous mental division during exposure to the fatiguing tone.

DISCUSSION

Some possible explanations may be offered to account for the failure of other investigators to obtain these results. Ward and Sweet[2] used a task involving the adding of columns of figures and failed to obtain a "mental task – reverie" difference under high-level (100 dB SPL) fatigue conditions. Barring the influence of some unknown procedural differences, it is possible that the task employed by Ward and Sweet was simply not so effective as the mental arithmetic condition used here and in the Wernick and Tobias study. Work in progress indicates that written computational tasks may not have the same effect on auditory fatigue that continuous mental division does.

Similarly, Bell and Stern[4] used written arithmetic problems (long division) instead of the continuous division task, and added a light tracking task as an additional condition. They compared the TTS obtained with these two tasks to that obtained under reverie with both a high-level (100 dB SPL) and a low-level (50 dB SPL) fatiguing tone and reported no significant differences between the task and reverie conditions. Their data do show, however, that the TTS was greater for the long division task than for reverie at both low and high levels in the first trials. That the differences obtained on the first set of trials were not greater and that they were not maintained with repeated trials might result from: (1) differences in the effectiveness of written long division and mental arithmetic, and (2) the fact that some tasks may lose their arousal value with repeated use.[6]

The Riach and Sheposh[3] study reported a replication of the Wernick and Tobias procedure but failed to obtain MA-REV differences in TTS with either high- or low-level fatigue. If the mean TTS obtained under the REV condition in the present study and in those of

Wernick and Tobias and of Bell and Stern may be used as a criterion, it would appear that Riach and Sheposh did not have appropriate REV conditions. They report a mean 10-sec TTS of about 9 dB for both MA and REV with low-level fatigue. The range of mean REV TTS values at similar levels in the other three studies was 2.1-4.3 dB.

CONCLUSIONS

The possibility of a central influence on auditory fatigue cannot be discounted on the grounds that the data result from chance variation. The choice of "mental task" and the instructions for "reverie" appear to be primary considerations in experiments designed to study differences in TTS as a function of mental activity.

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