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Comparison between effects of low and high frequency noise on mental performance

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ABSTRACT

Purpose: There are few and controversial findings about adverse effects between the low frequency noise (LFN) and high frequency noise (HFN) on human. Although noise is presumed as a distracting stimulus, regarding controversial findings between performance effects of LFN and HFN, and scarcely studies on dissimilar effects of them, the present study was conducted to answer the following questions: is there any difference between LFN and HFN impacts on mental performance at a moderate noise level? And, how do LFN and HFN affect mental performance?
Methods: This experimental study was carried out with 89 students (54 males and 35 females) of Tehran University of Medical Sciences. All participants performed the Stroop and Cognitrone tests in quiet condition, when exposing to LFN and HFN at both 50 and 70 dBA.
Results: It was found that both LFN and HFN augmented the performance through increasing sum hits and sum correct rejection and also decreasing working time of the Cognitrone test. The findings of the present study showed that not only LFN and HFN had no negative effects on the performance but also performance speed improved.
Conclusion: This experiment study showed no differences between LFN and HFN effects on the performance; moreover, both LFN and HFN improved the participants' performance. Of course, more researches are suggested in this issue.

1. Introduction

Mental performance can be defined operationally as the outcome of a task, effort, or activity that engages the central nervous system (CNS). There are many factors influencing mental performance such as ambient conditions, food intake, practice effects, and chronotype. ambient conditions including lighting, temperature, and noise [1,2]. Sound quality is one of the important factors affects the performance of subjects who are exposed to noise [3–6]. The response to noise may depend on characteristics of the sound, including frequency, intensity, complexity of sound, duration, tonality and the meaning of the noise [7,8].

There are few and controversial findings about adverse effects between low frequency noise (LFN) and other types of noise with different dominant contents of frequency-such as high frequency noise (HFN)-on human. LFN is usually defined as a broad band noise with the dominant content of frequencies from 10 to 250 Hz [9]. Some of the main sources of LFN in residential buildings are pumps, ventilating systems, and fans which could cause pollution inside and outside of a building [10].

LFN not only generates objective effects such as hearing impairment and body vibration, but also causes noise annoyance, behavioral disturbances, effects on sleep periods, deterioration of task performance, fatigue, headache and irritation [8,11–13]. To achieve a certain level of noise annoyance, LFN requires higher sound pressure level than higher frequency noise [8]. It has been shown that noise that has low frequency characteristics is more annoying than noise having other frequencies with the same A-weighted levels [14]. An experimental study showed that high frequency noises were more annoying than low frequency noises regardless of sex [15]. In addition, it was reported that HFN (frequencies from 500 to 8000 Hz) results in more errors in comparison with LFN, although this difference was significant only at high sound pressure level (100 dB) [16]. A laboratory study of the influence of sound quality on the annoyance caused by road traffic noise showed that high frequency noise contributes to listening interference [4]. On the other hand, it was announced that LFN could considerably decrease task performance in comparison with other dominant contents of frequency. LFN was rated as more annoying

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and more disruptive to working capacity than the flat frequency spectrum noise [11].

Many researches were conducted on the differences of LFN and other dominant contents of frequency effects on noise annoyance [5] but few studies have investigated on performance. On the other hand, the World Health Organization (WHO) has reported that the similarity and differences of LFN and HFN's effects were not examined [11]. Although noise is presumed as a distracting stimulus, regarding the controversial findings between performance effects of LFN and HFN and scarcely studies on dissimilar effects of them, the present study was conducted to answer the following questions:

- Is there any difference between LFN and HFN effects on mental performance at moderate a noise level?
- How do LFN and HFN affect mental performance?

2. Materials and methods

The present experimental study was conducted with 89 students (54 males and 35 females) of Tehran University of Medical Sciences, Tehran, Iran. The volunteer students were required to appear at the test hall. As an ethical issue, the detailed explanation of the experiment's purpose was offered to the participants; possible risks due to the experiment were explained and all participants were required to sign a consent form. The selected participants performed the hearing test and, if average hearing threshold levels were less than 20 dB, they were allowed to accomplish the mental performance tests. The hearing test was performed in un-echoing room by an audiometer (MEVOX ASB15).

The Un-echoing room was equipped with a PC monitor (12 inches diameter, resolution 786 ∗ 1024, and frequency of 69 HZ) and universal panel of Vienna Test System (Fig. 1). After locating the participants in the un-echoing room at first necessary instructions about the Cognitrone and Stroop tests were presented to the participants. Then, all participants performed the two tests in quiet condition. Next, LFN and HFN were emitted by Cool edit pro 2.1 at the level of 50 and 70 dBA. Before performing the tests by the participants, total sound pressure level and sound pressure level at octave band frequency were measured at participant head position by a sound level meter (B&K model 2238). After 30 min of noise exposure, the subjects started to perform the Cognitrone and Stroop tests. In order to reduce the recalling effect of the order of the figures presented in the Stroop and Cognitrone tests on results, 45 participants were exposed to LFN at first and then exposed to HFN, but 44 were exposed to HFN at first and then exposed to LFN. Furthermore, the half of the participants were firstly exposed to 50 dBA and the other were exposed to 70 dBA. In this study, the Cognitrone and Stroop interference tests were used for measuring mental performance. The Cognitrone test evaluates the concentration and attention through the identical comparison of figures [17]. In this research, S11 version (no time limit, short form) of the Cognitrone test was used. Four figures were displayed on top and one figure displayed under them. If one of four figures was identical with that down, the subjects must have pressed the green bottom and, if the figures were not the same, the red bottom must have been pressed. Sum hits, sum correct rejections and working time were considered as performance parameters of the Cognitrone test.

The Stroop interference test is a sensory-motor speed test registering speed performance when reading color words. S8 form of the Stroop test used in this research had two stages. In the first stage, participants must read the words without regarding the color of them and press the suitable button of a control panel. In the second stage, they must name the color of the words without regarding the meaning of them. The number of incorrect reactions (reading incongruent, number of incorrect reactions (naming incongruent)), and working time were considered as performance parameters of the Stroop test.

Before performing the tests, necessary instructions were presented to the participants and they were asked to act as fast and accurate as possible. To uniform the performance ability of the subjects during the tests all the trials were performed between 8.00 and 12.00 AM.

Fig. 1. Schematic figure of un-echoing room equipped with universal panel of VTS.

3. Results

In this study, the participants were 54 males and 35 females with an average age of 23.46 years (S.D = 1.97). The minimum and maximum ages were 19.80 and 30.20 years, respectively.

The frequency distributions of LFN and HFN emitted have been shown in Fig. 2. As can be seen from the figure, the pressure level of LFN noises in low frequencies was higher, whereas the reverse trend was seen for LFN.

The mean and standard deviations of performance parameters under different acoustical conditions in the Stroop interference test have been presented in Table 1. Paired *T*-test showed that there were no significant differences between performance parameters in the Stroop interference test (Table 2).

Table 3 shows the mean and standard deviations of performance parameters under different acoustical conditions in the Cognitrone test. As can be seen, a significant relationship was not observed among most performance parameters, especially between working time of tests in Cognitrone test (Table 4)

This experiment showed that the speed of test performing under HFN was less than that of LFN. In other words, participants under LFN performed the tests faster than participants under HFN. This has occurred for both 50 and 70 dBA noise pressure levels.

LFN and HFN at both levels of 50 and 70 dB increased numbers of sum hits and sum correct rejections in comparison with the quiet condition (Table 4). Moreover, duration of test performing of Cognitrone decreased in participants under noise (LFN and HFN) compared to the quiet condition. That is, both emitted noises (LFN and HFN) not only caused to escalation accuracy of respond-