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THE EFFECTS OF OFFICE NOISE ON PERFORMANCE RESPONSE TIME FOR SAFETY CRITICAL CONDITION

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ABSTRACT

Background: Noise is one of the factors which can effect on performance speed. These effects may depend on presser level and type of the noise. Non-auditory effects of noise in office is evidently necessary to obtain an appropriate assessment of the negative and positive values to employee.
Method: Sixty male subjects participated in this study. The computerized Stroop test was designed and used to measure selective attention under different noise condition including base, white, blue, pink noises and noise in 125,250,500,1000,2000,4000 Hz frequencies.
Results: the results showed that mean answering time increases noticeably at some frequency exposures. There is a significant difference in mean answering time 1 by the exposure to base noise and all of 8 noise types ($p<0.005$), except for white noise. Regarding mean answering time 1, there is a significant difference between mean answering time 2 in exposure to base noise and all of 8 noise types ($p<0.005$), except for the 4 kHz noise. The most noticeable effects on mean answering times where in 1, 2 kHz noise exposure, compared with base noise condition.
Conclusion: The results of study showed there is differences between noise type effects on performance and performance reaction declined more in 1, 2 kHz frequencies. This study demonstrated some of low level noises can declined performance speed.

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Introduction

Noise is one of the most effective environmental factors existent in workplaces due to the machineries operation with different frequency and also various sound levels[1]. Noise is environmental stressor and perceived nuisance as or unwanted sound [2]. Noise is recognized today as a serious problem for health in our environment and industries [3]. Some behavioral activities need stress through interference [4]. There are no data available in the published literature which clearly demonstrate harmful physiological non-auditory or psychological stress effects on man where noise per se is the sole or even the most direct cause of the stress [5]. Interference effects of noise on other activities, such as mental or motor work that does not involve auditory communications, has been studied extensively in the past [6]. There is some indication that impulsive noises cause, even after continued exposure, some slight arousal response; this response appears to have a negative, then a beneficial effect on task performance[7]. Number of correct responses, reaction time, and some symptoms of exposure to noise such as headache,

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fatigue and lack of concentration may be considered as performance indices [8, 9]. The influence to noise may depend on level and type of the noise, including level of pressure, frequency, and color of noise, exposure time and the meaning of the noise [10]. Some studies showed that noise may increase aggression and reduce the mental processing and task performance [11]. Non-auditory effects of low level noise in office is evidently necessary to obtain an appropriate assessment of the negative and positive values to employee [12].

Cognitive performance, annoyance and sleep disturbance are strongest environmental noise effects on health in adults and children [10]. Noise is one of the numerous environmental factors might influence performance in employee [13]. Performance might change by many factors of noise exposed persons. Both the noise frequency and the complexity of tasks, probably influence performance level [14]. Results of studies about noise and non-auditory effect are combined, but generally noise decline the performance [15]. Effects on performances of people cause stress factors, as reduction in productivity of the worker causes loss of profits for any company or industry [16]. Tasks performed during noise exposure unimpaired, after exposure tasks were impaired, this being reduced when people perceived noise control [17]. In noisy offices task performance is participant with hormonal response and extra physiological effort [18]. Office performance tasks in noise exposure condition was related to a slowing of the usual circadian reduction in salivary cortisol in subjects whose performance was also most impaired by noise [19]. High level of noise causes disturbance in understanding warning signs, vocal and could affect the safety through performance of individuals by affecting concentration and increasing risks related to health, inducing increasing errors, reducing efficiency and increasing decision time, and so on [20].

One of accident theory is domino theory from Henric. This theory identifies accidents by individual unsafe actions which these actions occur due to defect of performance caused by environmental factors [21]. Humans, by their very nature, has mistaken; so, it should come as no surprise that human error has been implicated in a variety of occupational accidents [22, 23]. Due to this non-auditory effects, the safety in the working places will be at risk and in case control rooms safety, appropriate controls and protective measures are not observed [24].All approaches contribute an event analysis and performance prediction have been pursued as two largely separate activities [25]. This paper presents that aim at studying the effects of Office noise on mental performance.

Method

Subjects:

Sixty male subjects participated in this study. All the subjects were process controller who monitored with computer systems. Each subject with normal hearing filled a GHQ screening questioner, and only those with normal mental health score of 22 were included in the study. The subjects signed informed consent for their participation.

Experimental design and procedure

Based on this study, the computerized Stroop test was designed and used to measure selective attention. This test was also designed in Persian language in which the number of correct answers, errors, and reaction and interference time was the criteria for scoring in the mentioned test. After the theoretical and practical training of the participants to make them familiar with the test, the performance time started during appropriate noise exposure. The test was continued for all type of defined noise. The experimenter had an interview with the participant before starting the formal experiment. The current test has two stages, first stage is named coloring test: in this stage, participants are asked to choose the color of the mentioned picture (for example, the color of the circle which is shown in four colors of blue, red, yellow and green) that can be selected by keys which are covered with colorful labels (V (blue), B (red), N (yellow), M (green)) on the keyboard, as they are shown on the screen of the monitor. The original performance of Stroop test is the second stage. In this stage, 48 chromatic consonant words and 48 chromatic non-consonants are shown (Consonant word is a word in which the color of the word is the same as its meaning on the monitor and non-consonant word is the word in which the color of the word is not the same as its meaning on the monitor). Totally, 96 consonant and non-consonant chromatic words have been presented randomly and consecutively. The task of the participants is to specify the apparent color of the words regardless of their meaning. The representation time of each stimulant on pageant is two seconds and the distance between two stimulants is 0.800 second. Researchers believe that the color word task (second stage of test) measures mental flexibility, interference and response inhibition (interference scale is achieved by subtracting the correct number of non-consonant score from the correct number of consonant score). The experimental design is shown in the (table 1).

Table1. Experimental design with time schedule

phase	Time (min)		procedure
1	5 10		Rest in a relaxing room GHQ questioner (if the score is lower than 22, the subject go to next stage; otherwise, the next person was replaced)
	3		Demographic information entry
2	10		Measurement of personal noise sensitivity
	17		Exposure to a specified noise
3		2	Self-assessment of noise annoyance
		15	Carrying out of Stroop test

	10	Rest in a relaxing room
	*	Repeat noise exposure by the next specified noise

Acoustic test room:

The experiment was carried out in a room with a surface of 10 m^2. This room was used to control other disturbing factors such as temperature, light and surrounding noise. The room conformity by OSHA 1910.95 App D. Air temperature was 20-21 ºC, humidity 45-55% and illumination was 300 lux in 6500 k. The noise was emitted from 6 loudspeakers, placed in the room, including 4 main loudspeakers, 1 subwoofer and 1 tweeter which could reproduce different frequencies. Normally, one subject performed the test session at any time.

Specified noise exposure

Ten type of noises were used include: Base, white, blue, pink noises and noise in 125,250,500,1000,2000,4000 Hz frequencies with flat-frequency character. The A-weighted sound pressure level of all noises was below 75 dB; the corresponding C-weighted sound pressure levels were below 75 dB for the reference noise and 65 dB for the other frequency noise.

A recording of a petrochemical control room noise, with rather flat frequency characteristics (measured in octave band), was used to create the base exposure noise. The specified noise characteristic was incorporated in the acoustic room to avoid other disturbing sounds from the surrounding. All types of noises were added by a noise generator and filtered by a resonance filter with a frequency regulator. A sinusoidal tone at any noise type was emitted. This was done to provide the specified noise frequency in exposure room. The processing of the sound was done using software and a digital sound processor system (Pioneer speaker SP-PK52FS). The equivalent octave band noise pressure levels of the emitted noises were measured at ear level at the position of a seated subject by a TES 1358 sound analyzer. The sound pressure level variation in the A-weighted at the 8type in the room was 70.3 dB

Analysis and statistical methods:

The statistical analyses were carried out using the SPSS, version 15. Repeated measures in linier model were performed to evaluate the influence of any type of noise conditions on the answering time. Sphericity assumed analyses were used to identify relationships between noise annoyance results, subjective reports and subjective sensitivity. All analyses were repeated, and a p-value below 0.05 was considered statistically significant, while a p-value up to 0.10 is reported as a tendency.

Result

In this study the effects of office noise on performance response time was investigated. (Table 2) shows the subjects demographic information.

Table 2 subjects demographic information

	Mean	Max	Min	SD
Age	33.9	40	22	3.4
Experience	6.4	15	1	3.9
General Health	9.3	16	3	3.5
Noise sensitivity	75	110	36	22.9

The results of Stroop test (crude mean answering time in 10 noise frequency groups) was showed in figure 1. Mean answering time for each word test were conducted in two type of chromatic consonant words (mean answering time 1) and chromatic non-consonants (mean answering time 2). Because of chromatic consonant is easier than non-consonants, mean answering time 1 is less than mean answering time 2. In some noise type men times have changes.

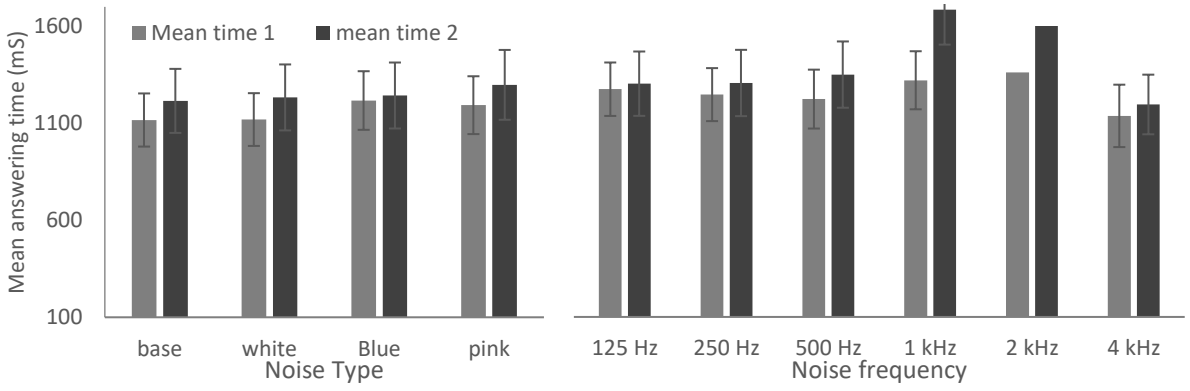

Figure1- The results of Stroop test: crude mean answering time in 10 noise frequency groups

As can be seen from (figure 1), mean answering time increases noticeably at some frequency exposures. To explore this increased time in greater detail a repeated measure was carried out, adjusted for age, experience, annoyance and noise sensitivity (table 3).

Table 3 Repeated measure analysis in mean answering times (adjusted by age, experience, annoyance and noise sensitivity)

Type of noise	Mean Difference		Sig.(a)		95% Confidence Interval for Difference(a)			
					Lower Bound		Upper Bound	
	Mean Time1	Mean Time 2	Mean Time1	Mean Time 2	Mean Time1	Mean Time 2	Mean Time1	Mean Time 2
White	-2.38	-17.83	0.300	<0.001	-6.94	-19.86	2.17	-15.80
Pink	-100.46	-27.65	<0.001	<0.001	-105.83	-30.69	-95.10	-24.61
Blue	-76.48	-82.68	<0.001	<0.001	-81.40	-87.57	-71.56	-77.79
125 Hz	-151.08	-80.80	<0.001	<0.001	-160.09	-94.70	-142.07	-66.89
250 Hz	-123.26	-84.30	<0.001	<0.001	-130.13	-99.53	-116.39	-69.06
500 Hz	-100.40	-127.53	<0.001	<0.001	-108.57	-141.71	-92.23	-113.35
1 kHz	-196.88	-461.11	<0.001	<0.001	-206.67	-478.48	-187.09	-443.74
2 kHz	-236.93	-375.91	<0.001	<0.001	-248.40	-393.39	-225.46	-358.44
4 kHz	-14.30	25.83	0.005	0.062	-24.00	-1.33	-4.59	53.00

Results show there were increases in both mean answering times. There is a significant difference in mean answering time 1 by the exposure to base noise and all of 8 noise types ($p<0.005$), except for white noise. This means that, white noise exposure cannot affect mean answering time 1. Regarding mean answering time 1, there is a significant difference between mean answering time 2 in exposure to base noise and all of 8 noise types ($p<0.005$), except for the 4 kHz noise. The most noticeable effects on mean answering times where in 1, 2 kHz noise exposure, compared with base noise condition (Table 3). (Figure 2) shows mean deference between diverse types of noise and the base noise condition.

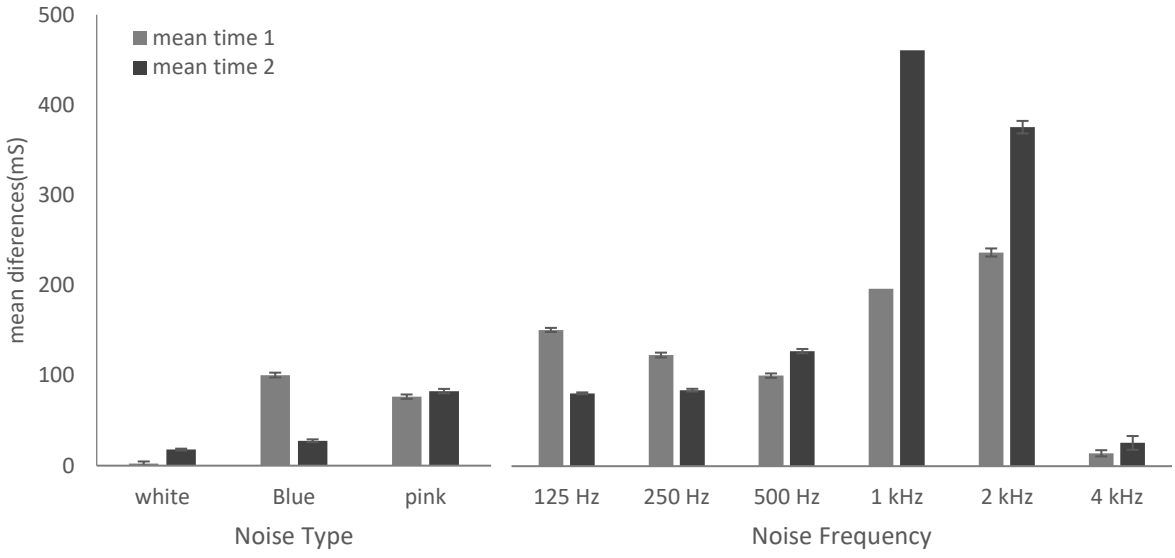

Figure3 mean deference between in the base noise and other types of noise exposure

Discussion

The findings showed that employee performance reaction declined more in 1, 2 kHz frequency of noise compared to the other type of noises, and they experienced more annoyance and less wellbeing with these noises. Significant frequency of noise can increase the negative effects of background noise in laboratory and offices. The noise of petrochemical control rooms have significance for performance and employee wellbeing in low level but some frequency. In complex tasks, performance was affected more than simple tasks in noisy condition. This reduction of attention level restricts the range of information processed and led to impair the performance.

The other purpose of this study was to clarify what type of noise can influence on decision speed in critical conditions. There were some high answering time that there may be an effect of 1-2 kHz noise frequency. In this study, noise sensitivity, age and experience was used as covariate factors but any of them had not meaningful influence. Our result provide new insights for the improvement of reaction time and the recognition of the specific contribution of occupational noise exposure, which should prove helpful to safety specialists in recognizing working conditions that could be more hazardous in control rooms.

There are many factors affecting performance of exposed persons to noise and therefore the study results are not consistent. Both the noise characteristics and the type of test, probably influence performance level. The findings of this study showed that time of test answer before and after exposure to noise have significant relation with frequency. Even for low level noise, employees working in offices declare they are disturbed by different sound sources and especially by intelligible speech.

Hagler and Goines has stated that noise could make alterations in performance and social behaviors of employees, such as increasing the rate of error, accidents, reducing concentration, memory, and the ability to solve problems, misuse of medicines, disappointment, and hopelessness [26]. This result is aligned our study. The results of Habibi study showed that average scores regarding discomfort before and after exposure to noise have significant relation with sound pressure levels [24]. The studies made by Khan and Smith, showed that sound may first have positive effects on performance, but in course of time with exposure to sound, this effect weakens [27, 28] but in our study exposure to low level of noise create adverse effects on performance in some type of noises. Although there are controversial results, but in many studies noise exposure has found to decrease the performance [29]. According to soltani theory if employee exposed to the lower or higher equivalent of noise level it might the performance be decrement [14] in our study frequency and type of noise are more effective in the performance.

Depending on the complexity and nature of a task, the experimental setting and the choice of subjects, noise levels sufficient for performance intrusion could be lowered to 51 dB(A) [30], that is aligned our study. Many of these industrial studies are difficult to interpret, however, because workers were exposed to other stressors such as physical danger and heavy work demands, in addition to excessive noise [10]. It is clear that there are other factors that may interact with noise exposure such as chronicity of exposure, other workplace exposures and, perhaps, perceived control over noise exposure [31]. There is a need for further research to clarify this complex area. Moreover, there should be a greater emphasis on field studies using longitudinal designs with careful choice of samples to avoid undue bias related to prior noise exposure.

Conclusion

The effects of office noise on performance response time in ten type of noises include: Base, white, blue, pink noises and noise in 125,250,500,1000,2000,4000 Hz frequencies was investigated. The results of study showed there is differences between noise type effects on performance and performance reaction declined more in 1, 2 kHz frequencies. This study demonstrated some of low level noises can declined performance speed. More researches are suggested in this issue.

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