



## Evaluations of Annoyance Due to Low-Level Noise in Control Room Officers

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### ABSTRACT

**Purpose:** One of the primary stress of noises on exposed people is annoyance. The aim of this study is to find the effect of diverse types of noise quality, independent of quantity, on annoyance and to investigate its non-auditory effects.

**Settings and Design:** This experimental study was carried out on 60 employers of petrochemical control rooms. Each subject, filled a GHQ screening questionnaire. The experiment was carried out in a measuring room that following by OSHA 1910.95 App D. Eight types of noises were used: white, blue, pink and typical narrow band sound in 125, 500, 1000, 2000, 4000 Hz frequency with flat-frequency character.

**Methods and Materials:** The level of sound pressure in A-weighted of both noises was below 75 dB. Subjects completed the noise sensitivity questionnaire. The noise annoyance was measured by the Likert scale. Statistical analyses were performed using the SPSS software.

**Results:** The result showed that there was a significant difference in annoyance by the exposure to all of 8 noise types ( $p < 0.005$ ). Noise exposure had the most noticeable effect by SPL 65-75 dB (A) in dominant frequency 500, 1000, 2000 Hz.

**Conclusion:** The results imply that noise annoyance are more sensitive to some types of noises. Low-level (65-75 dBA) noise affects the selected group of people that may be attributed to noise exposure.

**Keywords:** frequency, noise, annoyance

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### INTRODUCTION

One of the primary effect of noise on the exposed people is annoyance (Zannin and Bunn, 2014). Noise is harmful and an annoying factor that occurs for working persons (Amjad et al 2012). Noise annoyance is defined by the Environmental Protection Agency (EPA) as any negative subjective reaction on the part of an individual or group (Pedersen and Waye, 2007). Annoyance is a primary indicator of response because it attempts to account for negative aspect of effects from noise (Alimohammadi et al, 2010). The degree of disturbance depends on acoustic features, in particular the temporal microstructure (Gilavand and Jamshidnezhad, 2016). Studies of field and laboratory are performed to annoyance measurement and to obtain the number of the deferent variables. These variables dependent on personality, situation and preferences (Pedersen and Waye, 2007, Guski, 1999). Studies in laboratory on individual responses to noise determined some of the factors causing annoyance, such as level of noise, frequency aspects, time of exposure, information value, and activity interference (Miller, 1974). Environmental studies of human response to noise determined the dose-response relationship, which can be used to estimate the

amount of noise annoyance in people by any noise level exposure (Pedersen and Waye, 2004).

There are some casual factors which may influence individually to the human annoyance. The noise is not necessarily cause of these factors (Jakovljevic et al 2009). Newman and Beattie classify these casual factors in two groups: emotional (such as noise prevention, necessary to exposure, value and importance of noise source, human sensitivity, noise effects on health, fear feeling with the noise); and second group: physical (such as day time, season noise control on source) (Newman and Beattie, 2016).

Average sound levels are typically used for the evaluation of community noise effects (Schultz, 1978). Social longitudinal studies distinguish a statistical relationship between the high annoyance of some people and noise exposure in some level (Martin et al 2006). Noise produced by wind turbine is lower than industrial and traffic noises. But, noise annoyance by low levels of wind turbine is found higher than industrial and traffic noise at high noise levels (Seong et al 2013).

The effect of annoyance occurs even the audibility threshold is only slightly exceeded. There is the dominating effect of the influence of infrasonic and low frequency noise during occupational exposure on the human body (Engel, 2001).

Poorer intellectual efficiency and decreased productivity can be the main results of annoyance caused by infrasound and low-frequency noises. Annoyance caused by noises is influenced by a number of factors, both acoustic and individual, subjective ones, such as personal attitude towards the source of noise (noise acceptance), becoming accustomed, hearing sensitivity and individual sensitivity (Kaczmarek and Luczak, 2007).

Generally one can state that noise which is not tolerable even at low levels, and which is present in a room occupied by a person with highly sensitive hearing or high reactivity, or a person under stress or internal tension, during mental work, has a great influence on the mental condition and can cause different problems (Cooper and Marshall, 2013, Kaczmarek et al 2006).

Studies focused on the comparison between annoyance of railway and traffic noise have found that, railway noise annoyance is less than road traffic noise. Miedema et al. demonstrated these findings by a meta-analysis study. (Miedema et al 2001, Hygge et al 2003). Continuous noise interferes and distracts the processes of the working memory, with consequences for perception and the storage and the processing of acoustic and visual information (Martin et al 2000). Several studies found that noise sensitivity is a confound factor to noise annoyance. Sensitive persons who rate themselves were usually more annoyed by a noise (Van Kamp et al 2004) Therefore, human sensitivity could be considered as a personality attribute for the noise annoyance measurement in similar studies (Sandrock et al 2008). Environmental noise causes subjective discomfort which is assessed as reported noise annoyance (Miedema et al 2001, Schomer, 2005 and Babisch et al 2009). Exposure to even environmental noises, also causes physiological health effects, of which ischemic heart diseases and high blood pressure are the most investigated (Van Kempen and Babisch, 2012, Haralabidis et al 2008).

This study is conducted to satisfy the need for a better characterization of noise exposure, and to investigate any type of frequency spectrum of noise, by focusing on vulnerable selected groups and controlling mediating and confounding factors. It uses multiple outcome measures in laboratory studies and further considers the after-effects of a noise. The aim of this research is to find the effect of diverse types of noise quality, independent of quantity, on annoyance and to investigate its non-auditory effects with the purpose of the refinement of the general health outcomes.

## MATERIAL AND METHODS

### 3.1 Subjects

Sixty male subjects were staff of petrochemical control rooms. The subjects were all process controller by monitoring with computer systems, and had 20-40 years old. Each subject, with normal hearing, underwent a GHQ screening questioner. And only persons with normal mental health score (Fyhri and Klæboe, 2009) were included in the study. The subjects signed testimonial for their participation.

### 3.2 Acoustic test room

The experiment was carried out in a measurement room of 10 m<sup>2</sup>. This room was made to avoid other disturbing factors such as temperature, lighting and background noise. The room conformity by OSHA 1910.95 App D. air temperature was 20-21 °C, 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 loudspeaker, 1 subwoofer and 1 tweeter, which could reproduce frequencies. Normally, one subject performed the test session at any time.

### 3.3 Noise exposure

Eight types of noises were used: White, blue, pink noise and noise in 125, 500, 1000, 2000, 4000 Hz frequency with flat-frequency character. The A-weighted sound pressure level of both 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.

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 made in the acoustic room to avoid other disturbing sounds from the surrounding. All type of noise was 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 give the specified frequency noise in the 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 8 type in the room was 70.3 dB.

### 3.4 Experimental design and procedure

In the first stage all subjects completed noise sensitivity questionnaire to obtain personal sensitivity of subjects to noise (Figure 1).

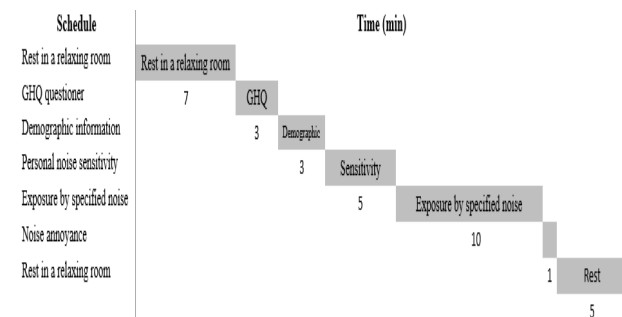
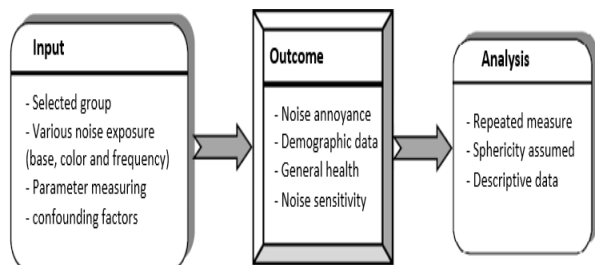


Figure 1. Experimental design with time schedule

### 3.5 Analysis and statistical methods

The experiment had 8 noise exposures for 60 subjects' noise annoyance, noise sensitivity and impressionable personality against noise. Repeated measures in the linier model, were performed to evaluate the influence of any type of noise condition on noise annoyance. Sphericity assumed analyses were used to identify relationships between subjective reports and subjective sensitivity. All data were analyzed by repeated measure, and a p-value below 0.05 was considered statistically significant, while a p-value up to 0.10 is reported as a tendency. The statistical analyses were carried out using the SPSS software (SPSS base 15.0 for Windows).

The tests of the noise type's effect on noise annoyance in laboratory conditions were conducted concurrently (Figure 2).



**Figure 2. General diagram of the study of noise type effect on noise annoyance**

**RESULTS**

The participant's age ranged from 22 to 40. Range of noise exposure in work place was 1-15 year. General health condition in participant was 3-16 of GHQ questionnaire and noise sensitivity in participant was 36-110 by Weinstein's noise sensitivity scale. Table 1 shows the summery information about the participants before the test.

**Table 1: participants' demographic data**

	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

Based on the type of noise being exposed to, noise annoyance in the participants is different. But, differences in noise conditions ( $p < 0.05$ ) cause significant differences. By Sphericity assumed statistical test, it was found that confounding factors such as age, experience have confounding effect. Noise sensitivity has not causal effect on noise annoyance (Table 2).

**Table 2: Covariate effect on noise annoyance**

Covariate	Pillai's trace	Sig.	Result
Age	0.375	0.002	yes
Experience	0.378	0.002	yes
Sensitivity	0.166	0.322	no
GHQ	0.224	0.115	no

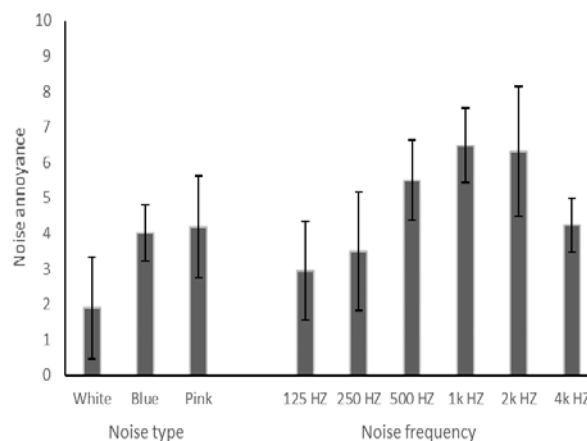
Mauchly's test showed greenhouse epsilon was 0.743. So, there was a deference between noise annoyances in different type of noises. Table 3 shows the differences between all types of the noise exposures.

The results revealed that noise annoyance in 1, 2 kHz is more than other noise exposures. Figure 3 demonstrates the mean of noise annoyance in different noise exposures.

(b)

	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
125 Hz	0.077	0.000	0.000	0.000	0.000

250 Hz	-	0.000	0.000	0.000	0.05
500 Hz	0.000	-	0.000	0.06	0.000
1 kHz	0.000	0.000	-	0.501	0.000
2 kHz	0.000	0.000	0.501	-	0.000



**Figure 3: noise annoyance mean in different noise exposure**

**DISCUSSION**

Through the study of annoyance produced by exposure to all noise types, we can conclude that:

- 1- 500-2000 Hz noise in 75 dB (A) can annoy people independent of age, noise sensitivity and rate of exposure;
- 2- There are no significant relationships between age, experience and noise sensitivity and noise annoyance;
- 3- Three meaningful noise was found to be more annoying than a meaningless noise.

Therefore, it can be concluded that serious steps should be taken in order to control noises. The qualitative aspect obtained for this study. Quantitative discussion of these results gives an anxiety about effect of low level noise pressure. One possible reason for the physiological responses to noise exposure can be an intermediate response, such as noise annoyance (Berenguer et al, 2004). Although this probable reason has not been clearly proved (Dratva et al 2010). Some of the noise-related studies have shown that noise exposure can cause annoyance as a possible mediating factor for cardiovascular outcomes (Oiamo et al 2015). Adjusting for age, smoking and index of body mass, between 3622 people of Serbia, men who had high annoyance, increased the risk of hypertension reporting (OR= 1.895% CI 1.0-2.4) and myocardial infarction (OR= 1.7 95% CI 1.0-2.9) than those who were not at all annoyed (Belojevic and Tanaskovic, 2002). Our study reports that if the annoyance was high, exposure to noise frequency leads to higher adverse effects. These results can be indicative of the fact that noise annoyance in people causes mental effects.

## CONCLUSION

The primary purpose of this study was to verify if there was any relationship between low-level noise by different dominant frequency and noise annoyance. In this study, it has been demonstrated that low-level noise affects the selected group of people who attributed to noise exposure. It is further suggested that further research focuses on doing a longitudinal industrial noise study, to determine the rate of annoyance from different types of noise. It is also proposed to control noises in frequency 500-2000 kHz at below the 65-75 dB.

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