Original Article

The impact of non-auditory effects of harmful industrials noise on Meta-Cognitive and Cognitive factors

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Abstract

Background and Aim: Noisy environment causes disruption in conversation and comprehension, decreased brain activity, and incoherence of physical work. The reflection that man makes on his mental processes, and the thinking about thinking, is called metacognition. The present study examined a set of cognitive factors to assess the cognitive status of employees. **Methods**: This cross-sectional observational was performed on 1000 workers of the Isfahan steel industry. ISO9612 (2009) and the job-based standard was used to measure the sound pressure level. At the same time, the VELZ Metacognition Questionnaire (MCQ-3) was used to measure cognitive components. The collected data were analyzed using SPSS statistical software and Chi-square, independent t-test, and Fisher tests. **Results:** In the study of workers' metacognitive skills, there was no significant difference in the subscale of negative beliefs about thought control and risks related to anxiety between the case and control groups ($p > 0.05$). But the scores of subscales of positive beliefs about anxiety, cognitive uncertainty, need to control thoughts and metacognitive processes of cognitive self-awareness in the case group were significantly lower than the control group ($p < 0.05$). **Conclusion:** The results of this study showed that noise has significant and destructive effects on the metacognitive skills of steelworkers. Therefore, it is necessary to take the necessary measures to increase mental health and reduce the vulnerability of this segment of society.

Keywords: Noise, Cognition, Meta-cognition, VELZ, Occupational disease, industrials.

INTRODUCTION

Sound is the most common occupational hazard in the world today. Numerous applied scientific and technological progresses in all fields of industrial machinery and equipment led to a considerable increase in the noise. Noise is an irregular, unwanted, and generally unavoidable wave that has no significant relationship between pressure amplitudes, frequencies, and wavelengths, and is often produced and propagated in the industry [(1)] Since the Industrial Revolution, noise and stress have been highlighted as a factor and the widespread epidemic of occupational hazard (not necessarily the most important) is known in various industries. The duration and intensity of exposure to noise are higher than in the past [(2).] In addition to various pollutants in the work environment, noise pollution is an important health issue in most industries, which, if not taken the necessary precautions, can cause physiological, psychological, economic, and social complications among exposed workers. There is no doubt that sound is one of the main problems of the industrial world and a large number of people in the workplace are at risk of adverse effects [.(3)] Therefore, along with the development of industries, a healthy work environment, and ensuring the health of working people who are the main operators of such industries should be considered [(4).] Research shows that workers all over the world, especially in developing countries, have this problem so that in Singapore, the most common work-related illness is hearing loss due to exposure to noise. Among workers exposed to noise in Korea, Hong Kong, Singapore, and the Philippines, 12, 15, 40, and 74

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percent of workers, respectively, had hearing loss of more than 30 decibels [5]. About 10 percent of the American population also suffers from a hearing loss that affects their ability to understand words correctly [6]. So that about 30 million American workers are exposed to harmful noise, which of course is about 35 million people in the European Union [7].

In the UK, it has been estimated that between 1 and 4% of the population is exposed to harmful or potentially harmful sounds, plus 12% of adults suffer from sensor neural hearing loss [8]. Considering the working population of Iran, according to the statistics of the Center for Occupational Health of the Ministry of Health, it can be estimated that more than 2 million workers are exposed to harmful occupational noise [9]. The effects of high-pressure sound levels can be seen in a variety of ways, such as causing physical damage (such as hearing loss) and psychological damage (such as stress and decreased concentration) [10, 11]. The effects of sound on the human body have been considered in several studies in several ways, such as; damage to the auditory system, interference with the conversation, effects on the visual organs, effects on the balance system, social distress, neurological and psychological effects, effects on electrolytes Noted, physiological effects and mental effects [12]. In recent years, stress measurements of hormones including adrenaline, noradrenaline, and cortisol have been considered as cardiovascular risk factors for people who experience noise [13]. The human body's reaction to loud noise is similar to reacting to imminent danger. These reactions include adrenaline secretion, changes in heart rate and blood pressure, feeling of pressure in the head and eyelids, fatigue, and difficulty concentrating [14]. Noise can impair hearing and communications, impairs concentration, fatigue, stress, and reduce productivity. Also, the physiological effects of sound are such that it increases the heart rate, respiration rate, and blood pressure [15]. In general, and based on the available evidence, human performance in the face of a sound source, especially when the sound is uncontrollable, can be significantly affected. Sound can make people feel empty, irritate them, change problem-solving strategies, and reduce their ability to focus on ongoing activities. It also affects social functioning and disrupts verbal communication [16]. The level of sound pressure to create negative effects on work performance is increasingly dependent on the type of task performed. The performance of individuals in simple mental tasks may also remain unchanged at very high volume levels, while more complex tasks may be impaired at low volume levels [17]. The term meta-cognition in the mid-70s by Flavell was suggested and as any knowledge or cognitive activity, that is those aspects of cognitive actions constructed. Zimmerman in 1990 stated that meta-cognitive actively monitor the knowledge and strategies to consider [18].In metacognition, people with high metacognitive power are careful in understanding the relationships between the facts of the problem, examine their chosen solution, analyze complex problems in small steps, and control the flow of their thinking by asking questions [19]. Meta-cognition is different from cognition, in that cognition involves mental processes such as thinking, reasoning, creativity, intelligence, or processes involved in information processing (accuracy, storage, and retrieval of information). While meta-cognitive is knowledge about different aspects of cognitive and learning how to use them to achieve the goals [20]. In metacognition, people with high meta-cognitive power are careful in understanding the relationships between problems, and propose their chosen solution in such a way that complex problems are analyzed in the form of small and simple steps, and by controlling themselves they can control the flow of their thinking [21]. Although the definition of metacognition seems challenging and difficult, most researchers agree with the fact that meta-cognition is knowing about knowing. More precisely, metacognitive knowledge is about how a person is self-learning [(22, 23)]. Metacognitive processes were defined with two independent but related items, meta-cognitive knowledge and meta-cognitive experience. Meta-cognitive knowledge is the science of the mind and its performance. Meta-cognitive knowledge is obtained when a person is aware of their cognitive abilities [24]. For example, according to the vertices, a person who is aware of his/her memory weaknesses, and takes notes to address them in time. This person 's awareness of the weakness of his memory is a kind of meta-cognitive knowledge that warns him to take appropriate action to compensate for his failure[25]. Theorists of this area believe that there is a distinction between two aspects of metacognition. These two dimensions are cognition and meta-cognition, which are used in metacognition to regulate activities such as planning, evaluation, and monitoring [19]. In addition, information about metacognition is obtained, often by subjective feelings that can have a positive or negative effect on people's behavior[26]. Cognitive levels have two levels, which include the meta level and the objective level [27]. Also, three types of meta-cognition include meta-cognitive knowledge, meta-cognitive experience, and meta-cognitive control strategies. Noise has different effects on humans such as sound effects on cognitive performance[28]. Noise sources affecting workers cause stress. Exposure to excessive standard sound can interfere with verbal communication and the perception of warning signs, which can affect the safety and performance of people [29]. Excessively standard exposure noise interferes with verbal communication and the perception of warning signs, which can affect the safety and performance of people. Sound as a source of stress for workers causes unwanted physiological responses and reduces the level of comfort during work[30]. Noise has different effects on humans, such as loss of cognitive function in individuals [(31, 32)]. Noise causes anger and mental confusion; for example, the sound does not have to be loud, even the ticking of the clock causes anger and aggression in the sensitive and susceptible people[33]. The psychological effects of noise vary from person to person, type, place of work, and time of day and night, but in general, a noisy environment can disrupt the conversation, reduce brain activity, and disorganize work [34]. The harmful effects of noise increase the number of mistakes [(35, 36)]. The

effect of physical factors such as noise on cognitive functions such as attention, accuracy, and reaction time is regarded[37]. Today, harmful noise is considered as an occupational hazard in the iron and steel, smelting, foundry, textile, and process industries[38]. Steelmaking is one of the most important industries in any country and the sources of sound propagation in this industry are diverse, which causes various complications such as hearing loss [(39)]. In the steel industry, the existence of special equipment and systems such as pumps, compressors, furnaces, motors, air blowing systems, cooling towers, gas and steam ducts and valves, electric arc furnace is the most important source of the sound. The sound pressure level in these units is between 97 dB (A) to 113 dB (A), which is higher than the allowable limit of 85 dB (A) [(40, 41)]. Due to the high noise in Iran Steel Company and various units, it is necessary to pay more attention to the cognitive and mental health of staff [(42)..

METHODS

This study is a cross-sectional observational study that was conducted in the steel industry. The first map of the hall with dimensions to specify and then study and implement measures with the sound of the model capable of measuring the level of his performance can be achieved by standard methods of iso9612. It is actually an engineering method to determine workers' exposure to noise in the workplace. The measurement results provide useful information to prioritize noise control measures. The measurement results obtained from this standard prioritize measures to provide voice control. It includes 5 main stages as follows: job analysis, measurement strategy, measurement, management errors and uncertainty assessment, calculation and presentation of results. This International Standard provides complete guidance for selecting an appropriate measurement strategy for a particular job situation and according to the purpose under consideration. For operators that are predictable and non-moving with complex work tasks to do, from Impedansometers, dosimetry was used. The dosimeter microphone is placed on the worker's shoulder at a distance of 10 cm from the entrance of the outer ear and on the side of the phone that has the most exposure to sound and at a distance of approximately 4 cm above the person's shoulder[43]. The advantage of using dosimetry is that it is not required for a worker who is monitored to be closely followed, and from a distance, several workers can be tested simultaneously [(44)].

In the analysis, the duties of each job, along with the time spent at the place looked and groups in terms of exposure to sound clear and sound pressure level continuous network A using a measuring device detected sound devices. To evaluate the effectiveness of sound change meta-cognitive skills Meta-cognition Questionnaire was used.

Meta-cognition Questionnaire (MCQ-3) is a self-report scale of 30 questions that was built in 1997 by Wales in which people's thoughts about their thinking can be assessed. Answers are calculated on a four-point Likert scale (1: Agree, 2: Slightly Agree, 3: Somewhat Agree, 4: Strongly Agree). The questionnaire has 5 subscales, which are positive beliefs about worry (questions 28, 23, 19, 10, 7, 1), negative beliefs about thought control and risks of anxiety (questions 21, 15, 11, 9, 4, 2), cognitive uncertainty (questions 29, 26, 24, 17, 14, 8), need to control thoughts (questions 27, 25, 22, 20, 13, 6), and meta-cognitive processes to evaluate self-awareness (questions 30, 18, 16, 12, 5, 3)[45]. The demographic information, which includes height and weight, age, level of education, duration of employment, marital status and medical history (heart disease, hypertension, kidney, and diabetes) was obtained through a self-declaration questionnaire. For verification of the information provided by the participants in the study, some questionnaires were randomly selected and the information included in them was compared with the information in the workers' health record[46].

The validity of the VELZ Metacognition Questionnaire (MCQ-3)

Anthony et al. (1998) studied cognitive parameters and aspects such as depression, anxiety, and stress. The results of this study showed that 68% of the total variance of the scale is measured by these three factors. The eigenvalues of stress, depression, and anxiety in the study were 9.07, 1.23, 2.23, and alpha coefficients for these factors were 0.97, 0.92, and 0.95, respectively. Also, the results of calculating the correlation between factors in the study of Anthony et al. (1998) indicated a correlation coefficient of 0.48 between the two factors of depression and stress, a correlation coefficient of 0.53 between anxiety and stress, a correlation coefficient of 0.53 between anxiety and stress and a correlation coefficient 0.28 between anxiety and depression. The validity and reliability of this questionnaire in Iran have been evaluated by Samani and Jokar (2007) who validated the retest for the depression, anxiety, and stress scale (0.80, 0.76 and 0.77, respectively), and Cronbach's Alpha for depression, anxiety, and stress were reported to be 0.81, 0.74, and 0.78, respectively. In examining the validity of this scale, the statistical method of factor analysis of the confirmatory type and principal components method was used. The numerical value of the index was equal to 0.9012 and also the X2 index in Bartlett sphericity test was equal to 3092.93 which was significant at the level of 0.0001 and indicated the adequacy of the sample and the variables selected for factor analysis. Based on the factor analysis, three sub-scales depression, anxiety, and stress were extracted by rotating on the items of the questionnaire and by using the specific values and slope of the scree plot. These subscales were in line with the main test factors of the VELZ Metacognition Questionnaire. (MCQ-3) [(45)].

Statistical analysis

The analysis of collected data was performed using SPSS 22 statistical software using descriptive statistics and Chi-square, independent t-test, correlation coefficient, and analysis of variance.

RESULTS

In the present study, 1000 workers of the Isfahan Steel Industry participated, of which 500 were assigned to the case group and 500 to the control group. The mean age of the workers participating in the study was 30.45 ± 3.28 years and their mean work experience was 5 years. All the workers in the study were men. In this study, 74% of the sample had undergraduate education, 21% had a diploma and 5% had a bachelor's degree or higher. 14% of the sample were single and 86% were married. 36% worked in day shift, 10% in night shift, and 54% on a rotating basis. There was no significant difference between case and control groups in the variables of education, marital status, and shift work (p-value> 0.05; Table 1). But the age of the subjects in the case group (33.06 ± 2.25) was significantly higher than the control group (27.84. 1.68) (p-value <0.001). Also, the work experience of the workers in the case group (9.90 ± 1.76) was significantly higher than the control group (7.22. 1.48) (p-value <0.001; Table 1).

Table 1. Comparison of demographic characteristics, work shift, and work experience in case and control groups (data are reported as % frequency)

Variable		p-value	groups	
			case n=500	control (n=500)
education	High school	0.860*	72%	4%
	Diploma		22%	20%
	Bachelor's degree and higher		6%	76%
marital status	Single	0.049*	18%	10%
	Married		82%	90%
shift	the day	1.00*	16%	54%
	the night		10%	5%
	Circulating		74%	41%
Age (standard deviation ± Mean)		<0.001**	36.06±2.25	28.84±1.68
Work experience (years) (standard deviation ± average)		<0.001**	9.90±1.76	7.22±1.48

* Chi-square test
**Independent T-test

Table 2 shows the results of multiple regression in which the relationship between the subscales of the VELZ Questionnaire (positive beliefs about anxiety, negative beliefs about the controllability of thoughts and risks related to anxiety, cognitive uncertainty, need to control thoughts and processes) is examined. Meta-cognitive self-awareness as variables related to demographic variables, shift work, and work experience were independent variables. In this study, simultaneous regression was used to select the independent variables affecting the model. Also, for each equation, among all the demographic variables entered in the regression model, only significant variables are reported in the table. The results did not show any significant relationship between demographic variables and negative beliefs about thought control and the risks associated with anxiety and the need to control thoughts. However, among the mentioned factors, age and marital status had a significant effect on positive beliefs about worry, shift and work experience on cognitive uncertainty and age on cognitive meta-cognitive processes (p-value <0.05 کTable 2). As one year of age increased, positive beliefs about anxiety decreased by an average of 0.441 points. Positive beliefs about anxiety in married people averaged 1.512 points higher than single people. Also, the cognitive uncertainty score in those who worked on a rotating basis was on average 0.457 points higher than those who worked night shifts. Also, this score was on average 0.457 units higher in night workers than in those who worked day shifts. On the other hand, with increasing one year of work experience, the cognitive uncertainty score decreased by an average of 0.291 units. Also, with increasing one year of age, the score of cognitive meta-cognitive processes decreased by an average of 0.167 units (Table 2).

***Table 2:** Relationship between demographic variables and subscales of the Velz Questionnaire

The dependent variable	independent variable	p-value	Regression coefficient (β)
Positive beliefs about worry	age	<0.001	-0.441
	marital status	0.021	1.512
Cognitive uncertainty	Shift working	0.032	0.457
	work experience	0.032	-0.291
Meta-cognitive processes of cognitive self-awareness	age	0.023	-0.167

* Only significant independent variables are reported in the table.

Table 3 compares the subscales of the VELZ Questionnaire (positive beliefs about anxiety, negative beliefs about controllable thoughts and risks of anxiety, cognitive uncertainty, need to control thoughts and meta-cognitive processes of cognitive self-awareness) in the case and control groups. The results of this study did not show a significant difference between the two groups in terms of negative beliefs about the controllability of thoughts and the risks associated with anxiety (p-value> 0.05). But the score of positive beliefs about anxiety, cognitive uncertainty, need to control thoughts, and meta-cognitive processes of cognitive self-awareness in the case group was significantly lower than the control group (p-value <0.05; Table 3). Figure 1 graphically gives a better picture of what was said above.

Table 3: Comparison of subscales of the Wales Questionnaire (positive beliefs about anxiety, negative beliefs about the controllability of thoughts and risks related to anxiety, cognitive uncertainty, need to control thoughts and meta-cognitive processes of *cognitive self-awareness) in case and control groups

Variable	groups		p-value#
	case (n=500)	control (n=500)	
Positive beliefs about worry	16.04±2.01	20.48±1.58	<0.001
Negative beliefs about the controllability of thoughts and the dangers of worrying	13.24±1.85	13.64±1.10	0.194
Cognitive uncertainty	17.42±1.81	19.10±1.74	<0.001
Need to control thoughts	15.80±2.32	16.80±1.39	0.011
Meta-cognitive processes of cognitive self-awareness	12.68±1.92	13.86±1.32	0.001

#Independent T-test
*Data are reported as the standard deviation ± mean

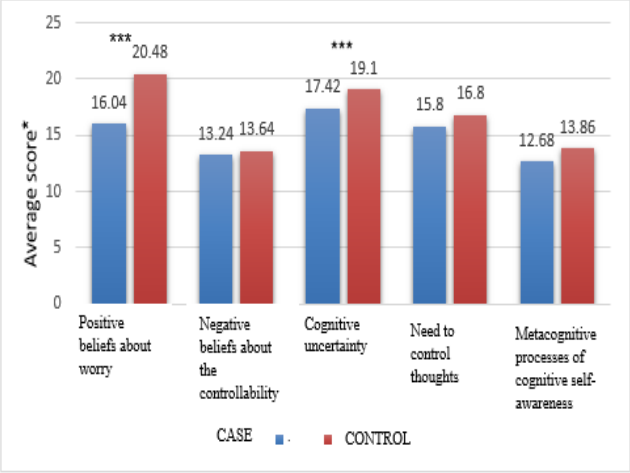

Figure 1. Comparison of positive beliefs about anxiety, negative beliefs about the controllability of thoughts and risks related to anxiety, cognitive uncertainty, meta-cognitive processes of cognitive self-awareness, and the need to control thoughts between the case and control groups. The results were obtained through independent t-tests and were reported as standard deviation ± mean (n = 50 in each group) in Table 3. *** show significant difference at the level of p <0.001, ** show significant difference at the level of p <0.01 and * show significant difference at the level of p <0.05.

Discussion

Research shows that workers around the world, especially in developing countries, face this problem. The effects of high-pressure sound levels can be seen in a variety of ways, such as causing physical damage (such as hearing loss) and psychological damage (such as stress and decreased concentration)[47]).

The present study is consistent with a study by Moradi in terms of increasing selective attention in the field of anxiety [(48)] and also in the workplace, especially in large and manufacturing industries. There is a significant difference between reduced performance and intelligible levels of sound. This study was consistent with a study to examine the effect of Brooklyn Lauren coverage on cognitive function and the noise was bothering people [(49)]. However, no significant relationship was observed between the cognitive factors in the present study and Jafari's study, because there were different statistical population and sub-cognitive factors and also, different results appeared in both human and mouse populations [(50)]. However, in the Bihang study, an obvious agreement was observed with the current study in terms of the effect of noise on concentration and performance, but the study population was different [(51)]. According to the results of the attention and concentration test, it has been shown that with the worsening of the combined conditions, the average score of attention and working memory decreases, which were statistically significant. The mean scores of working memory and attention in different conditions were lower compared to the group exposed to harmless levels, which showed a statistically significant difference in all conditions except exposure to low light. Therefore, simultaneous exposure to harmful levels of sound, heat and light has adverse effects on cognitive function parameters (working memory and attention), and with worsening conditions and contact with three factors at their own risk levels, the adverse effects increase. The effect of noise on cognitive performance parameters, was in line with study results of Yeend[52]. In the review articles between 2014 and 2017, we can see a very good study in this field. The study focused on the effects of noise on cognitive function. In the review of labels between 2014 and 2017, the effects of noise on cognitive performance were evaluated. The results obtained in this study of 82 articles showed that the noise has a significant impact on cognitive functions such as math, reading, writing, and word processing [(53)]. In the present study, unlike Baba Miri's study, the effects of sound pressure level and low-frequency sound on the components of cognitive function were investigated, which ultimately revealed that sound has negative effects on individuals [(54)]. The Cognitive Processing Questionnaire on Psychology and Environmental Noise Disorders can often be used as proposed by Surkwist. A distraction from environmental noise is often used as a tool that is essential for understanding selective attention span and short-term memory. In fact, it can be better said that in this study, noise has affected cognitive functions such as comprehension and word processing and memory performance [(55)]. The importance of metacognitive factors in current society and in every organ of human beings should be understood. Colthorpe investigated the importance of metacognition in learning and it was found that professors using the right factor MCT can do better in education and have better communication skills [(56)]. In large industries with high populations, cognitive function and cognitive factor are very important.

Conclusion

Due to the high level of sound pressure in some steelwork units and also the significant positive relationship between the decline of meta-cognitive and functional factors in the control group, effective preventive management measures have been proposed to prevent economic and health damage. Because long-term consistent assessments of cognitive components can lead to an understanding of the long-term effects of physical detrimental factors in the workplace. Also, it is recommended to do further research with behavioral models - MCT based on emotion regulation, commitment, and acceptance.

Ethical considerations

At the beginning of the research, permission was granted from the owner of the questionnaire to design the questionnaire. Confidential and anonymous is used only for the study, and the identities of individuals within the framework of ethics in research will remain confidential.

Conflict of interest

This study did not provide any conflict of interest for the authors.

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