THE EFFECTS OF ENVIRONMENTAL FACTORS ON JOB PERFORMANCE IN METAL INDUSTRY

Emin KAHYA[1*], Berna HAKTANIRLAR ULUTAŞ[2] , N. Fırat ÖZKAN[3]

[1]Eskisehir Osmangazi University, Engineering and Architecture Faculty, Department of Industrial Engineering Eskisehir – Turkey ORCID Number: http://orcid.org/0000-0001-9763-2714
[2]Eskisehir Osmangazi University, Engineering and Architecture Faculty, Department of Industrial Engineering Eskisehir – Turkey ORCID Number: http://orcid.org/0000-0002-0026-4925
[3]Eskisehir Osmangazi University, Engineering and Architecture Faculty, Department of Industrial Engineering Eskisehir – Turkey ORCID Number : http://orcid.org/0000-0003-4464-7052

Keywords

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Abstract

Environmental factors such as noise, temperature, humidity and illumination have direct or indirect effects on worker's job performance, productivity, occupational health and safety. Inappropriate conditions may decrease worker's concentration towards tasks which leads to low performance, poor quality, workplace hazards. It is important to assess which factor has effect to improve job performance and avoid accidents. The objective of this cross-sectional research is to investigate the effects of environmental factors on job performance. Data are gathered from 92 workplaces and blue-collar workers in eight manufacturing companies in metal industry. The average levels of 2760 measurements including four environmental factors are determined as 91.88 dB(A) for noise, 23.99 °C for temperature, 36.35% for humidity and 289.34 lx for illumination. The overall job performance score consisted of 15 contextual performance criteria is found as 3.30 of 5.00. The best performance for all the workers is identified as "Treatment the supervisor with respect" criterion. The results highlight the significant effect of noise on "productivity", temperature and illumination on "working systematically" and humidity on "quality".

METAL ENDÜSTRİSİNDE ÇEVRESEL KOŞULLARIN İŞ PERFORMANSINA ETKİLERİ

Anahtar Kelimeler

Çevre faktörleri, Sıcaklık, Gürültü, Nem, Aydınlatma, İş performansı, Verimlilik

Öz

Çevre faktörleri (gürültü, sıcaklık, nem, aydınlatma vb.), işyerlerinde çalışan işçiler üzerine, iş performansı, verimlilik, iş sağlığı ve güvenlik açısından dolaylı veya direkt etki ederler. Uygun olmayan koşullar, çalışanın görevlere karşı konsantrasyonunu azaltmakta, bu da düşük performans, yüksek ürün firesi, iş kazalarına neden olmaktadır. Hangi faktörlerin iş performansını geliştirme ve kazalardan kaçınmada nasıl etkiye sahip olduğunu değerlendirmek önemlidir. Bu çalışmada amaç, çevre faktörlerinin iş performans üzerine etkilerini araştırmaktır. Metal endüstrisinde faaliyet gösteren 8 işletmede 92 tezgah ve işçiden veriler toplanmıştır. Dört çevre faktörünü içeren 2760 ölçümün ortalama değerleri; gürültü 91,88 dB(A), sıcaklık 23,99°C, nem %36,35 ve aydınlatma şiddeti 289,34 lüks olarak belirlenmiştir. 15 davranışsal performans kriterini içeren iş performansı 3.30/5.0 bulunmuştur. Tüm işçiler için eniyi performans "Amirlerine saygı" kriterindedir. Sonuçlar, gürültü ile "Verimli çalışma", sıcaklık ve aydınlatma ile "Titiz ve düzenli çalışma", nem ile "Kalite" arasında anlamlı etki olduğunu göstermektedir.

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* Corresponding author; e-posta : ekahya@ogu.edu.tr

1. Introduction

In today's competitive world, it is important to use the resources in the best way to reduce costs, especially in small and medium-sized companies. Since, labour costs have the most critical importance among the others, it is necessary to prepare the work environment so that workers feel comfortable and perform effectively.

Interaction between people and their surrounding environment is one of the most important issues in all working environments (Vahedi and Dianat, 2014). In a work environment, there is a continuous and dynamic interaction between the workers and their surrounding environment that causes a number of physiological and psychological responses in workers, and consequently affects their comfort, performance, productivity, safety and health (Parsons, 2000; Dianat, Vahedi, and Dehnavi, 2016).

It has been acknowledged that the human responses to the environmental factors depend on a number of factors including physical, physiological and psychological as well as individual differences (Parsons, 2000). Thus, it is necessary to conduct studies in each working environment to find out how these factors will affect the workers in that work setting.

The workers who work under poor conditions may be less productive because they do not feel comfortable. Environmental factors such as illumination, ventilation, noise, temperature and humidity that do not meet the specified levels affect both physical and mental health of workers. These factors may also lead to accidents and occupational diseases (Kahya, Haktanırlar Ulutas and Ozkan, 2018).

The most efficient environmental factors considered in the metal industry are noise, temperature, humidity and illumination. Some authors have stated that the workers' feelings and performance directly depend on these environmental factors. Appropriate climatic conditions contribute to job performance. Chen, Chen, Yeh, Huang, and Mao (2003)'s results indicated the slow working pace at high temperatures and the increase in heart rate. Noise and mechanical vibrations have various negative consequences, from disturbing to permanent damage. Illumination enables to conduct the job smoothly and easily. Juslen, Wouters, and Tenner (2007) reported an approximately 3% increase in the speed of production of electronic assembly workers when the illumination level was increased from 800 lx to 1200 lx. Vahedi and Dianat (2014)'s study showed that the workers' satisfaction with lighting was also highly correlated with the workers' subjective assessments of the light level ($r=0.779$; $p<0.001$).

During the last few decades, there has been an increased concern about studies on the importance of the environmental factors in the literature. Some essential studies (e.g. Sönmez, Arslan, Ömer and Akdere, 2009; Chen et al., 2003; Juslen et al., 2007; Vahedi and Dianat, 2014; Dianat et al., 2016; Kahya et al., 2018) have reported the analysis of one or many environmental conditions. The physical measurements of environmental factors in each workplace were compared with the recommended standards (e.g. EN 12464-1 for lighting) in these studies. A large number of studies investigated the effects of environmental factors on job performance (Kahya, 2007), productivity (Shikdar and Sawaqed, 2003; Ismail, 2011), satisfaction (Dawal and Taha, 2006; Newsham et al., 2009; Dianat, Sedghi, Bagherzade, Asghari-Jafarabadi and Stedmon, 2013), stress and mood (Küller, Ballal, Laike, Mikellides, and Tonello, 2006), safety and health (Noweir, Alidrisi, Al-Darrab, and Zytoon, 2013; Kutlu, 2018) in manufacturing and service systems.

As one of the essential studies in recent years, Kahya (2007) investigated the effects of job characteristics and working conditions on job performance in a metal manufacturing plant. The results showed the substantial relationships between worker's performance, job evaluation and environmental factors. Poor workplace conditions result in decreasing worker's performance. Ismail (2011) analysed the effect of environmental factors (temperature, illuminance and noise) on workers' productivity in an automotive industry and the analysis results identified the relationship between environmental factors and workers' productivity. Dianat et al. (2013) conducted a field study to evaluate the illumination level, to examine the effect of lighting conditions on worker satisfaction, job performance, safety and health, and to compare the worker's perception of lighting level with actual illuminance levels in a hospital setting using both subjective (questionnaire) and objective (physical measurement) assessments. Most respondents indicated that at least one of the four lighting characteristics was inappropriate, and that at least one of the three lighting disturbances was a major

disturbance to them. Noweir et al. (2013) evaluated the progress of occupational safety and health in the manufacturing sector over a 20-years period. The evaluation was performed by walk-thorough survey and using a detailed survey form. The results indicated the temperature and noise levels were identified as the most uncomfortable environmental factors.

A large number of studies have been conducted in different industries for different purposes, dealing with the analysis of environmental factors in the literature. In the light of these findings, this research differed from previous studies in several important ways. This research is the first cross-sectional study investigating the effect of environmental factors on job performance in the metal industry. Secondly, the study investigates the levels of environmental factors on the widely used machines (e.g. press, guillotine shear, drill, lathe) in metal industry. The current research is also the first attempt to shed some lights on the issue of which environmental factor plays a more important role in influencing any job performance.

2. Method

This study, basically, focuses on the effect of environmental factors on job performance. It was conducted at eight medium and large sized companies in the metal sector in Eskişehir. An observation form was designed to evaluate such objectives as the levels of environmental factors and the effects on job performance. The form has three sections covering general information, environmental factors and job performance. General information includes company (name, number of workers, workplace where data are collected, production line), machine (name, process type, automation type) and worker (age, education level, experience level) information.

The research was approved by the Ethics Committee of Eskişehir Osmangazi University. Before starting the measurements, the manager of each company was visited and explained the purpose of the study and how the application would be carried out in detail. It was stated that all data would be kept confidential. The total of 2760 measurements including four environmental factors were collected from 92 machines. All the blue-collar workers who perform related tasks at these machines were considered to assess job performance consisted of 15 criteria.

2.1. Environmental Factors

It was aimed to take measurements from machines such as press (hydraulic or eccentric), guillotine shear, drill, lathe and grinding which are widely used in metal industry. The measurements for a machine were taken at three different times (morning, lunch and evening) of a day. During each time, 10 physical measurements were taken at approximately 2 minutes intervals throughout the machine to represent, as closely as possible, average level of the working area. A multifunctional portable meter (Extech Instruments EN300 Environmental Meter) was used to measure the levels of temperature, relative humidity, noise and illumination.

2.2. Performance Evaluation

Performance evaluations are objective analyses and syntheses designed to determine to what extent the skills of the staff meet the requirements and qualifications of the job or to determine to what extent they perform the tasks expected from them. Performance evaluation is the process of comparing the job standard with the worker's job performance to measure the degree to which the job is fulfilled. Borman and Motowidlo (1993) classified job performance under two categories: Task performance and Contextual performance.

Borman and Motowidlo (1993) defined task performance as "activities that contribute to the organization's technical core either directly by implementing a part of its technological process, or indirectly by providing it with needed materials or services". Task performance involves job related aspects that a particular worker is supposed to do at a given job. The job activities may include the quantity of work, quality of work done, speed of performing tasks, accuracy in work done and variety of the tasks being done or performed by the worker (Tufail, Mahesar, and Pathan, 2017).

Contextual performance is defined as individual efforts that are not relevant to the main task function but are important because they shape organizational, social and psychological conditions that serve as critical catalysts for task activities and process (Werner, 2000). Contextual performance including citizenship behaviour entails for activities

other than core job and is mostly related to factors such as peers, work place and supervision. Coleman and Borman (2000) grouped these behaviours in three categories: a) Interpersonal citizenship, b) Organizational citizenship and c) Job/Task Conscientiousness (job dedication)

The performance assessment in this study was a form of the contextual performance. As represented in Table 1, fifteen contextual performance criteria to evaluate workers' performance were taken from Kahya and Çemrek (2017). An evaluation form was designed including worker and job characteristics information and also job performance criteria. The form was filled in by the first supervisor of the worker during the observation. Each supervisor evaluated a worker through 5-Likert scale from 1= "fails to meet expectations" to 5= "clearly and consistently exceeds expectations"

Table 1.
Performance Assessment Criteria

Category	Sub Category	Criterion	Definition
Interpersonal citizenship	Altruism	Communication	Communication co-workers with personal matters
	Conscientiousness	Cooperating	Cooperating with others to solve problems
		Meeting	Participating in training meeting
Organizational citizenship	Allegiance / Loyalty	Punctuality	Exhibiting punctuality arriving at work on time in the morning and after lunch breaks
		Respect	Treatment the supervisor with respect
	Compliance	Safety	Obeying occupational health and safety rules
		Responsibility	Participating responsibility in the organization
Job Dedication		Working systematically	Working systematically
		Quality	Not making errors
		Concentration	Concentrating on the duties
		Innovation	Generating new ideas to make things (tasks) better
		Productivity	Working harder than necessary
		Planning	Planning and organizing work
		Creativity	Creativity to solve a work problem
		Self-development	Engaging in self-development to improve own effectiveness

3. Results

Statistical analysis of the data, including descriptive statistics as well as correlation, factor and regression analysis, was performed using SPSS software version 24.0. In all the analyses, p value < 0.05 were considered as statistically significant.

All workers in concern were male. The average age was 41.10 (std. dev. 8.39) and 75% of them ranged from 30 to 50 years. Half of the workers were primary school graduate. The average experience was 8.49 years and 66% is 1-21 years of experience. Fifty-nine (64%) of the machines were press (hydraulic and eccentric) and the others were guillotine shears, lathes, grinding and drill. 36% of them were automatic.

3.1. Environmental Factors

The noise levels varied between 82 and 110 dB(A) and 90% was above the recommended level 85 dB(A). The average noise level was calculated as 91.88 dB(A). Considering that the highest exposure action level in the relevant regulation is 85 dB(A), surprisingly, the results have indicated that the noise level in the metal industry is quite high. The average temperature level that has a close relationship with the outdoor temperature was 23.99°C. The workplace temperature was higher (~ 27°C) in summer and it was lower (~ 24°C) in winter times. The relative humidity was 36.35% on average. This value was 30% in autumn and winter, 36% in spring and 46% in summer time. The humidity was below the ideal level of 50% for 90% of the workplaces. The average illumination level was 289.34 lx. There was a considerable variation in the illumination levels

ranged from 33.2 lx up to 907.2 lx in different workplaces

Average, minimum and maximum levels of the environmental conditions based on machine types are given in Table 2. It is clearly seen that the noise level was higher for the machines where grinding, cutting and drilling operations were carried out on the sheet metal (~ 93 dB(A)) (Table 2.a). It is difficult to generalize the results for temperature and humidity levels. However, it was seen that illumination levels of the drilling machines such as lathe and milling, which are required for visual attention on the part, were higher as a result of the effect of local lighting. The noise level varied depending on the level of automation of the machines. The average noise level was 93.40 dB(A) in automatic and 91.07 dB(A) in manual machines (Table 2.b). The noise level in automatic machines was generally higher due to high production speed.

Table 2.
Environmental Conditions Based on Machine Types
a. Type of Machine

	Noise (dB(A))		Temperature (°C)		Humidity (%)		Illumination (Lx)	
Machine Type	Avg.	Min-Max	Avg.	Min-Max	Avg.	Min-Max	Avg.	Min-Max
Eccentric Press	93.41	85.17-106.38	24.54	19.11-29.74	36.16	24.01-54.72	299.23	38.67-902.70
Hydraulic Press	91.72	83.22-110.26	23.02	16.22-27.55	34.55	22.69-50.91	246.27	33.20-779.57
Guillotine Shear	92.39	86.69-102.53	25.15	20.04-29.43	39.78	31.34-48.60	265.44	51.60-568.87
Drill	87.41	82.93-91.31	21.96	21.15-22.97	40.26	29.23-54.92	335.87	228.40-466.47
Lathe	89.38	82.34-99.00	24.10	20.82-27.32	38.59	29.30-45.25	415.42	130.03-788.13
Grinding	93.20	82.26-107.59	25.77	21.69-29.73	31.95	27.13-39.30	214.94	111.40-383.67
Other	91.22	89.41-91.88	24.95	20.72-27.90	39.51	31.89-50.93	262.35	145.17-377.63

b. Automation Type

	Noise (dB(A))		Temperature (°C)		Humidity (%)		Illumination (Lx)	
Machine Type	Avg.	Min-Max	Avg.	Min-Max	Avg.	Min-Max	Avg.	Min-Max
Manuel	91.11	82.26-107.59	23.83	16.22-9.74	35.89	22.69-4.72	295.55	38.67-788.13
Automatic	93.27	82.93-110.26	24.28	20.04-7.93	37.18	24.49-4.92	278.79	33.20-902.70

The standard or legal limit is used as a criterion to determine whether the level of the environmental factor meets the standard or not. If the physical measurement is better (e.g. equal or lower) than the predetermined standard, the workplace around the machine in concern is named as “appropriate”.

Recommended standards or legal limits are summarized as follows:

Noise: Many of the research in the literature has focused on reducing the noise levels that the workers are exposed to for an 8-hour day to eliminate risk of hearing loss. OSHA has specified 90 dB(A) as the maximum permissible exposure to continuous noise for an 8-hour shift in US. Many other countries also regard 90 dB(A) as the maximum permissible level (Bridger, 1995). The related regulation in the country states that the highest exposure level is 85 dB(A). Therefore, each machine in concern was scored as “appropriate” if the noise level measured in that workplace was equal or lower than that recommended standard (85 dB(A)); otherwise it was evaluated as “not appropriate”.

Temperature: The human body produces heat, much of which must be released to the surroundings to prevent overheating. Therefore, comfortable climate condition may decrease when conducting heavy physical work, due to metabolic heat generating. Babalık (2016) stated ideal temperate ranges around workplace as follows:

- 18-24 °C for light work
- 17-22 °C for standing light work
- 15-21 °C for heavy work
- 15-22 °C for very heavy work

In this study, the tasks that are performed at press (hydraulic or eccentric), guillotine shears, drill, and other machines were considered as light (sedentary) work and the tasks that are performed at lathe, milling, grinding machines were defined as heavy work. It is clear that the ideal temperature range

slightly differs for the posture of the worker (i.e., standing or sitting) during the work.

Humidity: Acceptable range of relative humidity in a workplace may range between 40% and 70%. If relative humidity measured around the machine was between the recommended range, it was scored as "appropriate".

Illumination: The TS EN 12464-1: 2011 standard for "industrial activities related to metal processing" is stated as

- 300 lx for coarse and/or medium machining: tolerances > 0,1 mm
- 500 lx for fine and precise machining; Grinding: tolerances <0.1 mm
- 200 lx for machine processing for sheet metal: thickness > 5 mm
- 300 lx for working with sheet metal: thickness < 5 mm

Standard illumination levels for each machine type are as follows:

- Presses: 300 lx
- Guillotine Shears: 300 lx
- Drill: 500 lx
- Lathe and Milling: 500 lx
- Grinding: 500 lx
- Others: 300 lx

If the illumination level in the working area was equal or higher than the standard, it was evaluated as "appropriate".

Table 3 illustrates the appropriateness on the environmental factors for the machine types. The majority (71.74%) of the workers at drill, grinding, lathe and milling machines conduct the tasks while standing. On the other hand, the workers working on eccentric presses (46.67%) are more likely to conduct the cutting operations on small parts, while sitting.

Table 3.
The number of machines that meet the standards for environmental factors

Machine type	Total Number	Worker's posture		Noise	Temperature	Humidity	Illumination
		Sitting	Standing				
Eccentric Press	30	14	16	-	8	9	9
Hydraulic Press	30	9	21	1	9	4	7
Guillotine Shears	7	1	6	-	2	3	3
Drill	5	-	5	2	3	2	3
Lathe and Milling	10	-	10	2	2	4	4
Grinding	6	1	5	1	-	-	3
Others	4	1	3	-	1	2	3

93.48% of the machines had a noise level above the legal limit. Considering the recommended temperature levels, 72.83% of the machines were below the limits (1.09%) or above (71.74%). Especially the temperature for press machines was more acceptable levels. Humidity values were appropriate only for 26.09% of the machines where the rest of the values were identified as low humidity. The illumination level was satisfactory for 34.78% of the machines in concern.

3.2. Performance evaluation

Performance assessment results for each criterion are given in Table 4. The overall job performance was calculated as 3.30 (std. dev.= 0.69). Workers were very successful in the criteria "Treatment the supervisor with respect" (3.75), "Concentrating to the duties" (3.47) and "Obeying occupational health and safety rules" (3.45).

SPSS 24 package program was used to determine the correlation between age, education level, experience, and job performance. Pearson correlation coefficients are presented in Table 5.

Table 4.
The results for performance assessment

Category	Sub Category	Criterion	Mean	Std. Dev.
Interpersonal	Altruism	Communication	3.20	0.88
Citizenship	Conscientiousness	Cooperating	3.36	0.90
		Meeting	3.25	0.90
Organizational	Allegiance / Loyalty	Punctuality	3.34	0.94
Citizenship		Respect	3.75	0.86
	Compliance	Safety	3.45	0.88
		Responsibility	3.35	1.00
Job Dedication		Working systematically	3.32	0.89
		Quality	3.20	0.82
		Concentration	3.47	0.92
		Innovation	3.05	0.92
		Productivity	3.32	0.85
		Planning	3.33	0.83
		Creativity	2.95	0.91
		Self-development	3.13	0.94
Job performance			3.30	0.69

Table 5.
Correlation analysis for performance criteria
a. For performance categories

	1	2	3	4	5	6
1. Age	-					
2. Education level	-0.522**	-				
3. Experience	0.334**	-0.309**	-			
4. Interpersonal Citizenship	0.063	-0.037	0.155	-		
5. Organizational Citizenship	0.160	-0.168	0.206	0.725**	-	
6. Job Dedication	-0.023	-0.094	0.139	0.760**	0.753**	-
7. Job Performance	0.048	-0.110	0.171	0.870**	0.884**	0.960**

b. For important performance criteria

	1	2	3	4	5	6	7	8
1. Age	-							
2. Education level	-0.522**	-						
3. Experience	0.334**	-0.309**	-					
4. Safety	0.123	-0.121	0.052	-				
5. Responsibility	0.064	-0.122	0.109	0.546**	-			
6. Working systematically	0.093	-0.178	0.203	0.618**	0.692**	-		
7. Quality	0.045	-0.098	0.171	0.428**	0.604**	0.733**	-	
8. Meeting	-0.105	-0.028	0.117	0.386**	0.686**	0.589**	0.488**	-
9. Productivity	-0.038	-0.070	0.109	0.353**	0.632**	0.579**	0.655**	0.615**

*Note: **p<0,01, *p<0,05*

The most important criteria in performance evaluation are listed as follows:

- Obeying occupational health and safety rules (Safety)
- Participating responsibility in the organization (Responsibility)
- Working systematically
- Not making errors (Quality)
- Participating in training meeting (Meeting)
- Working harder than necessary (Productivity)

One of the most striking results was the negative relationship between education and age (r = - 0.522), experience (r = - 0.309) and job performance. Higher level of education constitutes to the lower performance level (r = - 0.11). More precisely, educated workers show low performance in all important criteria, considering that their works can be done by workers with lower education level. Similarly, there is a negative correlation between "Participating in training meeting" and "Productivity" and age. In other words, older workers do not want to participate in meeting and perform their work with lower productivity. There was a positive but weak correlation between experience and six performance criteria and job performance.

3.3. Factor analysis

Due to eliminating 8 biased data in performance ratings, factor analysis was conducted for the performance evaluations of 84 workers. First, the correlation matrix was examined in terms of the suitability of the factor analysis and it was seen that all the variables had at least one correlation coefficient greater than 0.3 that confirmed the suitability of the analysis. Since the total Kaiser-Meyer-Olkin (KMO) measure was 0.92 (above 0.70 for all variables), the grouping is classified as "Perfect". In addition, as Bartlett's test result was statistically significant (p <.0005), it was concluded that the data set was successful and significant.

Factor Analysis data set was divided into 3 factor groups explaining the variance change at 58.3%, 8.7% and 7.4%, respectively. Total variance of these groups was 74.4%. When the factor groups formed were examined, it was seen that the performance indicators collected in the first group were related to "doing the job well and adding value to the work". The second group is the collection of indicators related to "positive business relations and liking the job". It can be said that the last group contains indicators of "respect for rules and supervisors regarding the execution of the work" (Table 6).

Table 6.
Results of factor analysis

	Factor Groups		
Criterion	**1**	**2**	**3**
Concentration	**.751**	.146	.417
Planning	**.750**	.282	.136
Innovation	**.743**	.419	.072
Productivity	**.742**	.283	.226
Self-development	**.720**	.465	.157
Quality	**.705**	-.034	.545
Meeting	**.663**	.486	.137
Creativity	**.613**	.589	.130
Responsibility	**.603**	.481	.386
Communication	.262	***.827***	.253
Cooperating	.328	***.795***	.188
Punctuality	.222	***.670***	.470
Safety	.142	.216	***.812***
Respect	.150	.285	***.806***
Working systematically	.585	.201	***.654***

3.4. Effect of environmental factor on job performance

Correlation analysis results (Pearson correlation coefficients) between environmental factors and job performance are summarized in Table 7. One of the most remarkable results was the positive but weak relationship between job performance and temperature. The lighting conditions were weakly related to "Working systematically" (r = 0.155). The average humidity level of workplaces was 36.35% and this value was below the lower limit. The factor was found to be positively correlated with "Quality" performance criterion. The temperature had moderately and positively effect on ten criteria (r = 0.211 – 0.298). As the temperature increases, there are partial increases in most performance levels. This effect can be caused by the fact that the temperature level is not as high as to decrease job performance. The noise factor has a significant and positive effect on "Productivity" (r = 0.145).

Table 7.
Correlation analysis for environmental conditions and performance criteria

Criteria	Noise	Temperature	Humidity	Illumination
Communication	-0.022	0.050	-0.069	-0.016
Cooperating	0.039	0.051	-0.007	-0.063
Meeting	0.003	**0.250***	-0.093	0.120
Punctuality	0.121	0.183	-0.129	0.083
Respect	0.084	0.129	-0.085	0.003
Safety	0.044	**0.211***	-0.036	0.099
Responsibility	-0.024	**0.233***	0.008	-0.073
Working systematically	-0.001	**0.298****	0.041	**0.155**
Quality	0.007	**0.276****	**0.245***	-0.008
Concentration	0.122	**0.243***	0.043	0.074
Innovation	0.004	**0.243***	0.012	0.082
Productivity	**0.145**	**0.276****	0.056	0.043
Planning	-0.024	0.197	0.009	0.082
Creativity	-0.072	0.068	0.016	0.050
Self-development	0.071	**0.230***	0.083	0.039
Job performance	0.043	**0.255***	0.006	0.058

*Note: **p<0,01, *p<0,05*

Hierarchical multivariate regression analysis was carried out to evaluate the relative contribution of each environmental factor and worker's personal characteristics (age, education level and experience) for the prediction of job performance. In the regression analysis, five hierarchical regression models were established in order to identify the incremental effect of each independent variable. The effect of worker's personal characteristics was investigated in the basic model. For the next model, an environmental factor was added to the previous model and the effect of each factor was determined by the change in R^2. In each model, the effect of the included environmental factor was determined by the ΔR^2.

Table 8 reports the standardized coefficient, ß, R^2, ΔR^2 (change in R^2).

Basic model defined in (1) is given in the first column in Table 8.

Job Performance = 3.334 – 0.002 [Age] – 0.032 [Education] + 0.015 [Experience] (1)

Table 8.
Hierarchical multiple regression analysis results

Independent variable	Base Model	Model 1	Model 2	Model 3	Model 4
$ß_0$	3.334	2.821	1.831	2.124	2.131
Age	-0.002	-0.003	-0.002	0.000	0.000
Education	-0.032	-0.031	-0.044	-0.054	-0.054
Experience	0.015	0.015	0.016	0.015	0.015
Noise		0.006	0.000	-0.001	-0.001
Temperature			0.060	0.068	0.068
Humidity				-0.010	-0.010
Illumination					0.000
R^2	0.03	0.033	0.098	0.106	0.106
ΔR^2		0.003	0.065	0.008	0

Note: Dependent variable is job performance

Although age and education levels have a negative impact on job performance, experience has a minor effect on job performance. These three variables only affect 3% of the job performance. When the noise factor was added to the model (Model 1), the effect size (change in R^2) was 0.3%. Noise affects less than 1% of the change in job performance. When the temperature factor enters the regression model (Model 2), R^2=9.8%, the job performance is increased by 6.5% that points the important effect on job performance. On the contrary, the effects of humidity and illumination on the job performance were very low. While the humidity provided increase by 0.8%, the effect of illumination was not found.

4. Discussion

The most common environmental factors in metal industry can be listed as; noise, temperature, humidity and illumination.

High noise levels may weaken the concentration of the workers, reduce their attention and reaction capacity. Of the different possible effects of noise, one of the most important and clearly established is hearing loss (Sanders and McCormick, 1993). The duration of exposure to noise, intensity, frequency, intermittent or continuous, age of the person, sensitivity determine the degree of discomfort caused by the effect of noise. An exposure level of 85 dB(A) is often regarded, as preferable. The results showed that the noise level in the concerned companies varied between 82 and 110 dB(A) and 90% of them were above 85 dB(A). Higher noise in the working environment causes to permanent hearing loss. At the values of 105, 110 and 115 dB(A), with repeated exposure to noise of sufficient intensity, a permanent threshold shift will gradually appear after short working years.

The job performance of a worker changes depending on the effective temperature. After the temperature exceeds 25°C, the performance starts to decrease significantly. Sanders and McCormick (1993) stated that as the temperature is increased up to 34°C, performance rate decreases and can be only 50% of the initial level. The decrease in performance for heavy jobs is higher than the decrease for light work. For example, at about 26°C, performance loss is 10% for the light works and 44% for the very heavy works (Babalık, 2016). The average temperature around the machines in concern was 23.99°C (std.dev. 2.90°C). The press, guillotine, shear and drill processes can be called light works and the optimum temperature is recommended to be 18°C (17-22°C) (standing) or 20°C (18-24°C). Majority of the tasks were conducted in the environments over 18°C and half over 24°C. In autumn and summer, the workplace temperature was higher than 27°C that may reduce worker's performance by 30%. It is possible to use an air conditioning system to reach the ideal thermal conditions. Basically, fixed (purchase and install price, annual maintenance cost) and operation (energy) costs occur for such an investment. The optimum temperature levels can be enabled by considering the labour costs and related costs (i.e., cooling costs).

Preferred range of relative humidity for workplaces is between 40% and 70%. The average humidity was determined as 36.35% since the high humidity did not occur due to the nature of the concerned processes and the climate of the city. The humidity level was determined as 46% in summer time that was identified as appropriate for 26% of the workplaces in concern. For the rest of the workplaces (74%), the humidity level was determined to be below the lower limit. Action can be taken for low humidity levels for it can result in dryness in the nose and throat for the workers.

Illumination influences the performance of tasks in different ways (Sanders and McCormick, 1993). Adequate illumination is required in all workplaces to improve health, safety and job performance of the workers. Specially, poor lighting in the workplaces processing delicate tasks decreases worker's performance and increases costs. Considering the "the metal working industrial activities" category, the measured illumination levels in two-third of workplaces (68.50%) were identified as lower than the TS EN 12464-1: 2011 standard. Inadequate illumination is one of the highest risks for work accidents that may also result due to loss of attention, fatigue and sensing errors for the workers. Due to the importance of illumination in workplaces, maintenance should be planned and related investments should be made to enable the recommended level.

The research that aim to measure environmental factors in metal industry is limited in the literature. Chen et al. (2003) investigated melting and casting process in a steal plant in terms of environmental conditions. The results (30-32°C for temperature, 84-89 dB(A) for noise, 16.2-194 lx for illumination) confirmed that the nature of the process had an

impact to meet the standards. Due to the nature of the process (high temperature and dust), the results were much more inappropriate than those found in this study. Dianat et al. (2016) measured the environmental conditions indoor workplaces in three packing facilities. The average temperature (~26°C) was slightly higher than expected that might adversely affect job performance. The noise level was determined as 83 dB(A) which was below the standard level determined in this study. The illumination level (140-180 lx) was slightly lower than the legal standard. Dawal and Taha (2006) conducted measurements in two automotive manufacturing companies where temperature values were recorded as 32.2°C and 31.0°C, noise levels 70 dB(A) and 90 dB(A), humidity levels 69.1% and 60.2%, and illumination 567 lx and 540 lx respectively. The first company is identified as more problematic in terms of temperature and humidity.

The results of this study for environmental factors are consisted with the limited research in the literature. The contribution of this study is to focus on the metal industry and evaluate workplace based on tasks conducted at the machines and their types (automatic or manual). Further attention is attracted to the job performance of the workers.

It is known that more credit is given to the blue-collar workers who are more successful in terms of creativity, self-development and innovation. The workers who participated in this study had very successful scores in the criteria of "Treatment the supervisor with respect", "Obeying occupational health and safety rules" and "Concentrating to the duties". On the other hand, "Generating new ideas to make things (tasks) better" (3.05), "Creativity to solve a work problem" (2.95) and "Engaging in self-development to improve own effectiveness" (3.13) had lower performance scores.

The workers performed the jobs under the expected for the criteria "Not making errors" (3.20), "Working systematically" (3.32) and "Working harder than necessary" (3.32), which are known as the most important criteria for job performance. However, workers were not identified as to be successful for the criteria in the "Job dedication" category that is as essential as task performance.

The performance scores for categories were identified as follows:

- Interpersonal Citizenship: 3.27
- Organizational Citizenship: 3.47
- Job Dedication: 3.22

The workers were not much successful for the criteria in the job dedication category, which are essential as much as task performance.

A negative correlation was observed between education and age (r = -0,522) and experience (r = -0,309) in the correlation analysis between age, education level, experience and job performance. These results illustrate that workers who have longer experience had lower education levels, and newcomers had a higher level of education. The correlations between job performance and age (r = 0,048), education (r = -0,11) and experience (r = 0,171) confirm that as the level of education increases, the job performance decreases. On the other hand, the elderly and experienced workers perform better that may be result of interpersonal and organizational citizenship.

Several studies in the literature have discussed the potential effects of demographic variables (i.e., age, gender, education level and experience) on job performance. The results confirm indirect or direct effects of work experience and education level on the performance. Kahya (2009) stated that a correlation coefficient between experience and performance range between 0.09-0.18. Correlation results of recent studies that focus on job performance are as follows:

- ❖ education (r = 0.063) and experience (r = 0.057) (Kahya, 2007)
- ❖ education (r = 0.053) and experience (r = 0.116) (Maroofi and Navidinia, 2012)
- ❖ education (r = -0.025) and experience (r = -0.062) (Kahya and Çemrek, 2017).

In addition, although older and experienced workers show higher performance in the category of "Organizational citizenship", they have failed more in all three categories of performance criteria where higher educated workers performed better. The workers were more successful for quality, efficiency and meticulous and regular work.

The workers who are graduates of machines or metal programs of vocational high schools should be assigned to the tasks at the machines that require mechanical knowledge. Nearly half (45%) of the workers working in the companies were primary school and /or secondary school graduates. Workers with low levels of education are expected to be experienced and old workers, hence they were hired

years ago. Based on the experience levels of these workers, it was determined that about half of them had less than 5 years of experience and 20% of them were experienced less than a year. As expected, the majority of vocational high school graduates (65%) were employed in the last 10 years. Although the level of education does not guarantee an increase in the performance, it is expected that the trainings on safety, quality, creativity, etc., may help to increase their contextual and task-based performance as well as making more accurate decisions on risk and critical issues such as machine failure. Therefore, it is recommended that the graduates of vocational high schools should be preferred in the employment of workers performing the tasks at the machines such as press, guillotine shear, and lathe.

Correlation analysis between the environmental factors and job performance highlighted a positive but weak relationship. Similar results (r= 0.058) were presented in Kahya (2007). Temperature was the most affecting factor of job performance. Other positive and significant correlations were introduced as follows:

- Noise and "productivity"
- Temperature and illumination and "working systematically"
- Humidity and "quality".

These results are consistent with the findings of the studies on environmental factors and job performance or productivity (Juslen et al., 2007; Kahya, 2007; Ismail, 2011; Dinat et al., 2016). Kahya (2007) calculated the correlation between environmental factors and quality (r = -0,166) and productivity (r = 0,141). Juslen et al. (2007) indicated a positive but weak correlation (r = 0.043) between illumination and productivity and stated that the increase in illumination speed of the production by approximately 3%. Ismail (2011), in the regression analysis, resulted three factors to have a negative effect on job performance.

5. Conclusion

In this study, a total of 2760 measurements were taken from 92 machines including press, lathe and guillotine shear at 8 manufacturing companies in the metal industry. By analysing the data, the levels and distributions of environmental factors were determined. Based on the accessible literature, this is the first study to consider environmental factors (objective measurements) and job performance in a large number of manufacturing companies in the metal sector.

The levels of four environmental factors, compared to the recommended standards and legal limits, in the 92 machines were found appropriate as 6.5% for noise, 27.17% for temperature, 26.09% for humidity and 34.78% for illumination. The overall performance was affected weakly but positively by the environmental factors. Environmental factors mostly affect behaviours in the "job dedication" category that is as important as "task performance". On the other hand, environmental conditions had effects on contextual performance such as productivity, working systematically and quality. The noise and humidity effect productivity and quality; while temperature and illumination had an effect on working systematically. The workers who work under poor environmental conditions do not feel comfortable and have lower performance. Environmental factors under or above of standard limits have negative effects on workers regarding physical and psychological health, cause of work accidents and occupational diseases.

The one-way analysis of variance (One-Way ANOVA : Post Hoc Multiple Comparison) results are summarized as follows:

- There is no significant difference between companies except for a company in terms of noise and illumination.
- It is not possible to generalize difference among companies regarding to temperature
- Humidity is ~30% for a half of companies, ~45% for the others.

It is clear that the climatic factors (temperature and humidity) depend on the season but environmental factors do not change among companies and then the results can be generalized for the metal sector.

This study has a number of limitations that need to be taken into account when interpreting the results. The most essential limitation is the basis of the assessment because job performance results were based on subjective reports. The validity of supervisors' assessment as performance indicators have also been widely criticized in the literature (Kahya, 2007; Vahedi and Dianat, 2014). To obtain more reliable results, it is suggested to define objective and quantifiable indicators for the performance measures such as productivity ratio, percentage of products that was rejected (quality),

and the number of suggestions acquired from company record.

The findings of this study may not be generalized for other task environments because the study is conducted at eight medium and large-sized companies that have consent. Among 698 companies registered to "Chamber of Industry", 83 of them fall in metal processing category. Therefore, to strengthen the generalization of findings, future studies may focus on other companies to consider more measurements.

Each environmental factor affects different job performance criteria at a different level. The results indicated the importance of environmental factors in workplaces to increase job performance. To improve workers' job performance, quality, productivity and safety, it is important to improve environmental working conditions as to meet the national and international standards.

Conflict of interest

The authors declare no conflict of interest.

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References

Babalık, F. (2016). *Mühendisler için ergonomi - İşbilim-* Fifth Ed., Bursa : Dora.

Borman, W.C., & Motowidlo, S.M. (1993). *Expanding the criterion domain to include elements of contextual performance*. Chapter in N. Schmitt and W. C. Borman (Eds.), Personnel selection in organizations (pp. 71-98). San Francisco: Jossey-Bass.

Bridger, R.S. (1995). *Introduction to ergonomics*, Singapore : McGraw-Hill.

Chen, M. L., Chen, C. J., Yeh, W. Y., Huang, J. W., & Mao, I. F. (2003). Heat stress evaluation and worker fatigue in a steel plant. *AIHA Journal*, 64(3), 352-359. doi: https://doi.org/10.1080/15428110308984827

Coleman VI, & Borman W.C. (2000). Investigating the underlying structure of the citizenship performance domain. *Human Resource Management Review*, 10(1), 25-44. doi:https://doi.org/10.1016/S1053-4822(99)00037-6

Dawal, S.Z.M., & Taha, Z. (2006). The effect of job and environmental factors on job satisfaction in automotive industries. *International Journal of Occupational Safety and Ergonomics,* 12(1), 267-280. doi: https://doi.org/10.1080/10803548.2006.11076687

Dianat, I., Sedghi, A., Bagherzade, J., Asghari-Jafarabadi, M., & Stedmon, A.W. (2013). Objective and subjective assessments of lighting in a hospital setting: implications for health, safety and performance. *Ergonomics,* 56, 1535-1545. doi:https://doi.org/10.1080/00140139.2013.820845

Dianat, I., Vahedi, A., & Dehnavi, S. (2016). Association between objective and subjective assessments of environmental ergonomic factors in manufacturing plants. *International Journal of Industrial Ergonomics*, 54, 26-31. doi: https://doi.org/10.1016/j.ergon.2015.12.004

Ismail, A.R. (2011). Multiple linear regressions of environmental factors toward discrete human performance. *Proceedings of the 4th international conference on environmental and geological science and engineering (EG '11)*, 15-17 September 2011, WSEAS Press, Barcelona, Spain.

Juslen, H.T., Wouters, M.C.H.M, & Tenner, A.D. (2007). Lighting level and productivity : A field study in the electronics industry. *Ergonomics,* 50 (4), 615-624. doi: https://doi.org/10.1080/00140130601155001

Kahya, E. (2007). The effects of job characteristics and working conditions on job performance. *International Journal of Industrial Ergonomics,* 37(6), 515-523. doi:https://doi.org/10.1016/j.ergon.2007.02.006

Kahya, E. (2009). The effects of job performance on effectiveness*. International Journal of Industrial Ergonomics,* 39(1), 96-104. doi: https://doi.org/10.1016/j.ergon.2008.06.006

Kahya, E., & Çemrek, F. (2017). An investigation on the ratings from four sources for different positions in a 360 degree feedback system, *Eskisehir Osmangazi University Journal of Economics and Administrative Sciences,* 12(3), 49 – 64. doi: https://doi.org/10.17153/oguiibf.329898

Kahya, E., Haktanırlar Ulutas, B. & Ozkan N.F. (2018). Analysis of environmental conditions in metal industry, *Journal of Engineering Sciences and*

Design, 6(1), 38-46. doi: https://doi.org/10.21923/jesd.351690

Kutlu, R. (2018). Çevresel faktörlerin mekan kalitesi ve insan sağlığına etkileri. *The Turkish Online Journal of Design, Art and Communication*, 8(1), 67-78. Retrieved from http://acikerisim.iku.edu.tr/handle/11413/3201

Küller, R., Ballal, S., Laike, T., Mikellides, B., & Tonello, G. (2006). The impact of light and colour on psychological mood: a cross-cultural study of indoor work environments. *Ergonomics*, 49, 1496-1507. doi: https://doi.org/10.1080/00140130600858142

Maroofi, F., & Navidinya, F. (2011). The measurement of job performance and its impact on effectiveness. *International Journal of Performance Management*, 12(3), 217-227. doi: https://doi.org/10.1504/IJBPM.2011.039887

Newsham, G., Brand, J., Donnelly, C., Veitch, J., Aries, M., & Charles, K. (2009). Linking indoor environment conditions to job satisfaction: a field study. *Building Research & Information,* 37, 129-147. doi: https://doi.org/10.1080/09613210802710298

Noweir, M. H., Alidrisi, M. M., Al-Darrab, I. A., & Zytoon, M. A. (2013). Occupational safety and health performance of the manufacturing sector in Jeddah Industrial Estate, Saudi Arabia: A 20-years follow-up study. *Safety Science*, 53, 11-24. doi: https://doi.org/10.1016/j.ssci.2012.09.005

Parsons, K.C. (2000). Environmental ergonomics: a review of principles, methods and models. *Applied Ergonomics,* 31, 581-594. Doi : https://doi.org/10.1016/S0003-6870(00)00044-2

Sanders, M. S., & McCormick, E. J. (1993). *Applied anthropometry, work-space design and seating. Human Factors in Engineering and Design*, Seventh Ed. McGraw-Hill, Singapore.

Shikdar, A.A., & Sawaqed, N.M. (2003). Worker productivity, and occupational health and safety issues in selected industries. *Computers & Industrial Engineering*, 45(4), 563–572. doi: https://doi.org/10.1016/S0360-8352(03)00074-3

Sönmez, A., Arslan, A. R., Ömer, A. S. A. L., & Akdere, B. (2009). Assessment of physical environment conditions of small and medium-scale enterprises being active in the furniture sector in Ankara. *Journal of Polytechnic,* 12(2) 127-135.

TS EN 12464-1 : 2011 *Standard. Light and lighting - lighting of work places*. TSE. Accepted date : 31 January 2012.

Tufail, M.S., Mahesar, H.A., & Pathan, S.K. (2017). Organizational justice, task and contextual performance: empirical analysis for front line managers. *Grassroots,* 51(1), 269-281. Retrieved from http://sujo-old.usindh.edu.pk/index.php/Grassroots/article/view/3262/2368

Vahedi, A., & Dianat, I. (2014). Employees' perception of lighting conditions in manufacturing plants: associations with illuminance measurements. J*ournal of Research in Health Sciences,* 14, 40-45. Retrieved from http://journals.umsha.ac.ir/index.php/JRHS/article/view/1039

Werner, J.M. (2000). Implications of OCB and contextual performance for human resource management**.** *Human Resource Management Review,* 10(1), 3-24. doi: https://doi.org/10.1016/S1053-4822(99)00036-4