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Sources of Situation Awareness Errors in Workplace (Stress, Sleep Loss and Fatigue) in National Petrochemical Company in 2014

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Abstract

Aim: It has been shown that workers who had previously been involved in a work accident had significantly lower situation awareness scores than those who had not had an accident in the workplace. In this study, we examined the role of stress, sleep loss and fatigue in predicting situation awareness among workers.

Methods: The current study was a cross-sectional study. The sample consisting of 180 employees in National Petrochemical Company in 2014 was selected according to the stratified random sampling method. They responded to questionnaires about work situation awareness, work stress, sleep loss and fatigue. The data were analyzed by correlation techniques and stepwise regression.

Findings: The results showed a significant internal correlation among work stress, sleep loss and fatigue, and work situation awareness. Also the results of stepwise regression analysis showed that sleep loss, fatigue and stress predicted, respectively, almost 25%, 23% and 21% of variances of work situation awareness among workers.

Conclusion: The variables of stress, sleep loss and fatigue could predict work situation awareness. Therefore, these variables can be important to promoting the awareness of work situation among workers.

Keywords: Stress, Sleep loss, Fatigue, Situation awareness

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Introduction

In most occupational accidents, there is a causal chain of organizational conditions and person errors [1]. Reason [2] concluded that human-factor causes can be attributed to 70–80% of occupational accidents in high-hazard industries. One critical element in predicting occupational accidents is the ability of employees to maintain an adequate understanding of their work situation [3]. In industrial companies, the necessary attentional skills are referred to as 'Situation Awareness' (SA). Endsley [4] defines SA as: ''... the perception of the elements in the environment within a volume of space and time, the comprehension of their meaning, and the projection of their status in the near future''. SA has been further studied in the aviation industry [5]; in recent years, studies have been performed in such fields as aircraft maintenance, the military, driving, anaesthesia, the maritime industry, and nuclear power plants [6]. Cognitive skills like work situation awareness are known to be susceptible to the elements of work-related conditions such as work stress and sleep loss and fatigue [7], which are common in many high-risk industries and organizations. Ongoing research of the causal events shows failures in situation awareness and risk assessment [8]. So, it is important to identify factors reducing work situation awareness.

High stress can result in reduced working memory capacity and diminished attention [9]. The high levels of stress can result in poor concentration/alertness due to an overload on the person's cognitive resources; this can interfere with the primary perception of the situation, causing inattention to the available information, and data in the surrounding environment. Consequently, there may be a narrowing of the individual's attentional field to incorporate only a number of key aspects in his/her surrounding environment, resulting in peripheral information receiving little or no attention [3]. While this 'cognitive tunnel vision' may be an important adaptive strategy in a dangerous environment by preventing work overload, elements outside the main centralization of attention may be those that have most potential to be harmful [10]. Relatively high levels of work stress have been measured in studies done in the oil and gas industry, and relationships between stress and accident rates have been established [11].

Sleepiness and fatigue cause damages to alertness levels, and consequently, increase the risk involved in the job injuries [12], as the cognitive resources required are depleted due to physical actions or sleep deprivation [13]. The previous research showed [14] that defects in cognitive processing in persons with only moderate sleep deprivation and fatigue were similar to those experienced when blood alcohol levels were over the legal limit for driving. The effects of fatigue due to

sleepiness are to reduce the speed of cognitive processing, and therefore, increase reaction times, tunnel vision, inattentiveness, and lower vigilance and concentration [15]. These effects have also been reported in the maritime [16], transportation [17], and oil and gas industry [3]. Based on this, the aim of the current research is to investigate the relationship between stress, sleep loss and fatigue with work situation awareness among workers.

Materials and Methods

This cross - sectional study was administrated between October and November 2014 in The National Petrochemical Company (NPC), Iran. In this study, with respect to the extent and distribution of the employees in the different parts of this company, stratified random sampling was used to select sample members. In stratified random sampling, the strata are formed based on the members' shared attributes or characteristics. Using the Krejcie and Morgan Table [18], 200 employees were selected; however, 4 members due to lack of interest in research topic, and 6 members due to incomplete questionnaires (in total 10 people) were excluded from the study. 180 completed questionnaires were collected, and the return rate was 90%. The time required to fill out a questionnaires was 45 minutes. Written informed consents were obtained from all participants. The inclusion criterion for a person to this study was employment at the company's sectors, and selection from among the members of his/her group randomly. The exclusion criteria were the delivery of incomplete questionnaire, and lack of interest in participating in the current research. All participants stated their satisfaction on participating in this research in order to avoid bias in answering questions in the questionnaire. Also a covering letter explained the purpose of the study, and that participation in the study was confidential and guaranteed. They were ensured that their responses would be confidential, the responses will not be seen by the managers and supervisors any way, and the results will be evaluated collectively, not individually. The respondents were asked to return the completed questionnaires inside the sealed envelopes either to the person who had distributed them or directly to the research team. This study was approved, and was financially supported by the Research Committee of Faculty of Psychology and Educational Sciences of Allameh Tabataba'i University, and the National Petrochemical Company. No ethical hazard is known to the authors of the research.

Demographic factors

Six demographic factors, namely age, gender, marital status, education, years of working experience and shift were included. Marital

status was classified as married or not married (including divorced and widowed).

Work Situation Awareness (SA) [19]

SA with 20 items on a 5-point Likert-type scale (0=very often; 5=never). This scale had acceptable internal reliability (Cronbach's alpha = 0.86) and good validity. The validity coefficients of questions were between 0.25 and 0.79, and all the validity coefficients were significant at $p<0.0001$.

Perceived Job Stress Scale (PSS)

This scale measures the degree to which situations in one's life are rated as stressful [20]. Scoring is based on a Likert-scale format from never (0) to very often (4). This scale had validity (reliability = .84, .85, and .86 in three cases), high internal reliability (0.79=Cronbach's Alpha) and acceptable validity. Internal consistencies (Cronbach's α) in this study, in Iran, for the occupational stress, perceived job self-efficacy and perceived job helplessness were, respectively, reported as 0.83, 0.75 and 0.87, which are excellent for these scales [21].

Epworth Sleepiness Scale (ESS)

The ESS with 8-items [22] has been designed to determine a participant's likelihood to doze off or fall asleep in different situations. All items are rated on a scale of 0-3; a score above 10 is considered positive for excessive daytime sleepiness (EDS). The cut-off scores higher than 10 have 93.5% sensitivity, and 100% specificity to distinguish EDS from normal daytime sleepiness [22]. Reliability of this inventory, in this research, was calculated by Alpha coefficient of 0.77 and Split-half of 0.73. The validity coefficients of questions were between 0.23 and 0.88, and all are significant at $p<0.0001$.

Fatigue scale

This scale is a 14 - item questionnaire of Chalder, Berelowitz & Hirsch [23] that is measured the physical and mental symptoms of fatigue. Scoring is based on a Likert style of five degrees from 0 (never) to 4 (very much). Prior studies surveying many industrials and organizations provide evidence for high internal reliability and criterion validity of the scale. Reliability of this scale, in this research, by Alpha Coefficient was 0.88 and by Split-half was 0.83. The validity coefficients of questions were between 0.22 and 0.84, and all are significant at $p<0.0001$. The Statistical Package for the Social Sciences (SPSS) version 15 was used to analyze the data. Also descriptive statistics were used to summarize and organize the data. The data were analyzed by stepwise regression analysis.

Results

In this study, the subjects' mean age was 38

+4.14 years. The most education group was MA degree, and 35% of the participants had work experience of 5 years and lower. 72.5% of the subjects had a history of shift work, and 90% were married (Table 1).

Mean, standard deviation and internal correlations of the variables under study are presented in (Table 2).

Table 1: Demographic characteristics of the sample members (N=180)

		Frequency	Frequency percentage (%)
Age	18 to 29 years	49	27.5%
	30 to 41 years	122	67.5%
	42 to 53 years	9	5%
Marital status	Married	162	90%
	Single	18	10%
Education	M.Sc. (M.A.) degree or higher	58	32.5%
	B.Sc. (B.A.) degree	49	27.5%
	High school graduates	73	40%
	Primary school graduates and lower	-	-
Work experience	5 years and lower	63	35%
	6 to 15 years	43	24%
	16 to 25 years	43	24%
	26 years and higher	31	17%
Shift status	Shift	130	72.5%
	Not shift	50	27.5%

Table 2: Mean, Error Standard and internal collections of the variables

			Correlations			
Variables	$\bar{X}$	**SD**	**1**	**2**	**3**	**4**
Stress	35.13	6.12	1			
Sleep loss	37.97	7.21	0.29**	1		
Fatigue	40.17	5.13	0.19**	0.73**	1	
Work situation awareness	64.65	8.14	-0.53**	-0.55**	-.54**	1

As can be seen, there are significant relationships among stress, sleep loss, fatigue and work situation awareness ($p<0.01$).

Stepwise regression analysis was used to assess the predictive power of work situation awareness by stress, sleep loss and fatigue variables. The results of model summary are presented in Table 3.

Table 3: Summary of regression analysis model

Variable	R	R^2	ΔR^2	ΔF	Sig.
Step 1: sleep loss	0.55	0.30	0.30	16.57	.000
Step 2: sleep loss and fatigue	0.69	0.47	0.17	13.11	.002
Step 2: sleep loss, fatigue and stress	0.74	0.54	0.07	9.37	.005

The results of regression model for explaining work situation awareness based on stress, sleep loss and fatigue indicated that F-statistic for both models was significant at $p<0.01$. Therefore, there was the possible explanation of work situation awareness based on both variables. The regression coefficients of stepwise regression analysis are presented in table 4.

Table 4: Summary of stepwise regression analysis to predict work situation awareness based on stress, sleep loss and fatigue

Variable	B	B	SE B	t	R^2	Sig.
Sleep loss	-0.44	-0.55	0.15	-3.41	0.25	.000
Fatigue	-0.43	-0.41	0.22	-3.81	0.23	.001
Stress	-0.39	-0.26	0.07	-3.61	0.21	.003

As can be seen, sleep loss variable with β=-0.44 can significantly predict almost 25% of the variance of work situation awareness. Fatigue variable with β=-0.43 can significantly predict almost 23% of the variance of work situation awareness. Also stress variable with β=-0.39 can significantly predict almost 21% of the variance of work situation awareness.

Discussion

The result of the current research showed stress variable significantly predicted work situation awareness among workers. This is consistent with the findings of the previous studies [19], and can be interpreted on the basis of the following possibilities: Individuals reporting higher levels of stress were found to have poorer work situation awareness. The literature shows that stress has a tendency to cause persons to narrow their field of attention and can impair cognitive functions by undermining working memory [24]. High levels of stress can result in poor concentration/alertness as a result of an overload on the person's cognitive resources. Stressors can be physical, such as vibration, crowding, noise, pollution, temperature, and high/low light levels [24]. Factors that feature predominantly are nearly unavoidable in the harsh Oil and Gas industrial environment [11]. The most common effect is narrowing of the attention field to a restricted number of main elements, whereas data on the periphery is less likely to be encoded. The high levels of stress from several directions were also thought to affect situation awareness—as heavy workload increases (it was felt that it was more difficult to focus on a task if there was a lot of work ongoing, as attention had to be divided among several tasks, and also there was the danger of attention narrowing to concentrate on one task, sight of the 'big picture' could be lost, and can cause to reduced working memory capacity and diminished attention); supervisor pressure

(to get a job done quickly), and self-imposed pressure to complete a work by a certain time [3]. The levels of occupational stress on Oil and Gas industrial installations have been measured in a series of studies, and relationships with accident rates have been established [11].

The results further showed That sleep loss and fatigue variables significantly predicted work situation awareness among workers. This is consistent with the findings of the previous studies [25], and can be interpreted on the basis of the following possibilities:

Wallace and colleagues [26] concluded that individuals who scored higher on day-time sleepiness and fatigue also experienced more cognitive failures. Fatigue due to sleep disruption in the petroleum and chemical industries is part of working; this is detrimental to employees to decrease their work situation awareness levels [3]. Lorist and colleagues [27] concluded that mental and physical fatigue cause to impaired cognitive control and decreased situation awareness. McDonald et al. [28] in the simple tests of attention and concentration indicated that some impairment in situation awareness was influenced by fatigue. Decreased attention and increased cognitive errors are an obvious result of physical and mental fatigue among employees. So, tired workers lose their vigilance and alertness, and therefore, cannot pay attention to the workplace conditions.

Unfortunately, there are conditions and many factors in the working environment that cause fatigue in the individuals. One of these factors is the change in shift workers. Many employees work in a shift pattern (known as 'short change') involving the workers to change half-way through day-shift to night-shift or vice versa) that results to disrupting sleep patterns and increasing fatigue [29]. Workplaces conditions, generally, tend to be noisy due to machinery and equipment. Moreover, there are high numbers of workers living and working in a limited area; workers also may share an accommodation cabin, which can disturb relaxation time and sleep and increase fatigue among them [30]. Companies and industrials can consider altering the shift patterns that are in place to make them more stable, e.g. allow employees to always work a day or night shift rather than switch shift patterns in the middle (split/swing shift), or installing extra sound proofing in cabins to allow workers to enjoy more undisrupted sleep and thus reduce fatigue among them.

Conclusion

The findings of this research emphasize the importance of stress, sleep loss and fatigue variables in predicting work situation awareness among workers. It is recommended

that the future research examine the effects of safety interventions on increasing situation awareness. Furthermore, with designing these interventions and with more attention to them, we can affect one of the most important influential variables in the incidence of occupational accidents. The present study needs to be replicated in different populations and requires more empirical support. Till then, the findings of the study should be interpreted with caution. In addition, the cross-sectional design of the study and participants (i.e., a group of employee) exert some limitations on the generalization of the findings.

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