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How does the Positional Awareness of Workers Decrease? The Role of Fatigue and Work-related Stress Variables

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ABSTRACT

Background: An important factor in preventing industrial accidents includes the ability of employees to have awareness of the work situation, understand the information from it, and predict how situations will develop. In this study, we examined the role of fatigue and work-related stress in predicting work situation awareness among workers.
Methods: The current study was a cross-sectional study. The sample consisted of 180 employees in the National Petrochemical Company in 2022 year that was selected according to the stratified random sampling method and responded to questionnaires about demographic characteristics, work situation awareness, work stress, and fatigue. The data were analyzed by correlation techniques and stepwise regression.
Results: The results showed that there was a significant internal correlation between research variables. Also, the results of stepwise regression analysis revealed that fatigue and work stress significantly predicted, respectively, almost 11% and 16% of variances in work situation awareness among workers.
Conclusion: According to the findings of the present study, fatigue and work-related stress can predict work situation awareness. Therefore, considering these variables can be significant in promoting work situation awareness among workers.

1. Introduction

After several catastrophic events (most notably the Piper Alpha disaster in 1988 in which 167 workers died; [1]), oil and gas companies are making every effort to ensure that their occupational accident rates are kept as low as possible [2]. In most occupational accidents, there is a causal chain of organizational conditions and personal errors [3]. Researchers conclude that human-factor can be attributed to the occurrence of occupational accidents in high-hazard industries [4]. One critical element in predicting occupational accidents is the ability of employees to show an adequate understanding of their work situation. This means being fully aware of job duties and workplace conditions, and judging how these may change in the near future to predict how the situation will develop [2, 5]. Cognitive psychologists have long been interested in attention [6], and the role of cognitive skills in safety issues is well documented [7]. In industrial companies, the necessary attention skills are referred to as 'situation awareness' (SA). SA is defined by Endsley [8] 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 [9]; aircraft maintenance [10], the military [11], driving [12], anesthesia [13], the maritime industry [14], and nuclear power plants [15]. Cognitive skills such as work situation awareness are known to be

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susceptible to the variables of work-related conditions such as fatigue and work stress [16, 17] which are common in many high-risk industries and organizations; for example, in oil and gas exploration, where employees work on remote installations, often in high time-pressured, dangerous conditions [18]. Ongoing research on causal events shows failures in situation awareness and risk assessment [19]. So, it is important to identify factors influencing work situation awareness. Fatigue causes damage to alertness levels and consequently increases the risk involved in job injuries [20], as the cognitive resources required are depleted due to physical actions or sleep deprivation [21]. Researchers concluded that defects in cognitive processing in persons with only moderate sleep deprivation and fatigue were similar to the time when one′s blood alcohol levels are over the legal limit for driving [22]. Fatigue reduces the speed of cognitive processing and therefore increases reaction times, tunnel vision, inattentiveness, and lower vigilance and concentration [23]. These effects have been also reported in the maritime industry [24], and transportation [25], and have also been reported in the oil and gas industry [2]. Also, high stress can result in reduced working memory capacity and diminished attention [26]. The high levels of stress can result in poor concentration/alertness due to an overload on the person′s cognitive resources, and this can interfere with the primary perception of the situation, and cause inattention to the available information and data in the surrounding environment. Consequently, it may narrow the individual′s attention to only some key aspects of her/his surrounding environment, resulting in peripheral information with little or no attention [2, 7]. This ‘cognitive tunnel vision′ may be an important adaptive strategy in a dangerous environment by preventing work overload [27]. High levels of work stress have been measured in studies done in the oil and gas industry [28] and relationships between stress and accident rates have also been confirmed [29]. The variables affecting work situation awareness were poorly understood and more studies are required to identify them. So far, little research (particularly in Iran) about work situation awareness carried out and the percent research is new. With attention to the above materials, the current research aimed to investigate the relationship between fatigue and work stress with work situation awareness.

2. Materials and Methods

This cross-sectional study was administrated between October and September 2022 in The National Petrochemical Company (NPC). Considering the extent and distribution of the employees in the different parts of this company, we used stratified random sampling. A random sample from each stratum was taken in a number proportional to the stratum size when compared to the population. These subsets of the strata were then pooled to form a random sample. Then, we applied simple random sampling or systematic sampling within each stratum. This often improves the representativeness of the sample by reducing sampling error. It can produce a weighted mean that has less variability than the arithmetic mean of a simple random sample of the population. The sample size was calculated using SPSS (version 15), following the procedure recommended by Molavi [30]. Given an, α level of 0.05 and a power of 90%, the sample size required was estimated to be 180 subjects. Given the likelihood of failure to complete or return the questionnaire, almost 190 employees were selected using stratified random sampling and questionnaires were distributed among them. Informed consent was obtained from each participant and was approved the research by the constituted ethics committees where the work was done. The entry criterion for a person to this study was employment at the company's sectors and the selection from the group members randomly. The exclusion criterion of the individual was the delivery of an incomplete questionnaire and lack of interest in participating in the current research. 4 members of the sample were excluded from the main sample due to lack of interest in the research topic, and 6 members were due to incomplete questionnaires (in total 10 people). 180 completed questionnaires were collected. In order to control the confounding factors, questionnaires were completed by sample members in a quiet environment. In order to avoid bias in answering the questions, employees stated their satisfaction with participating in this research. Also, a cover letter explained the purpose of the study to the participants. Participating in this study was confidentially guaranteed. Furthermore, they were given to ensure that their responses would be confidential and responses by managers and supervisors will not see anyway and the results will be evaluated collectively, not individually. Respondents were asked to return completed questionnaires inside the sealed envelopes either to the person who had distributed them or directly to the research team. Valid instruments were used for the data collection on work situation awareness, fatigue, and work stress. At first, all questionnaires were translated from English into Persian and independently back-translated into English by a second translator. The few discrepancies between the original English and the back-translated version resulted in an adjustment in the Persian translation based on direct discussion between the translators. In the next step, the psychometric characteristics of the instruments were examined. Linguistic validation was performed by three experts from the psychology department and five experts from the safety and health departments. Thus, the questionnaires were piloted and finalized with an advisory group of workers to ensure that the scale items were comprehensible and appropriate to the context. Moreover, conceptual analysis confirmed the content validity of all instruments. The questionnaires were distributed to workers with the help of a union steward. Participants were assured of confidentiality and informed consent in written format was acquired from each of them. The following questionnaires were used:

2.1 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).

2.2 Work situation awareness (SA)

SA with 20 items of Sneddon, Mearns, and Flin [17] was measured. Respondents indicated the extent of agreement with each statement on a 5-point Likert-type scale (0 = very often; 5 = never). The questions on this scale consisted of 5 positive questions such as: "I think ahead of my work to plan for different possible outcomes" and 15 negative questions such as: "I am easily distracted by my thoughts or feelings". Sneddon et al. [17] calculated this scale to have acceptable internal reliability (Cronbach's alpha = 0.86) and good validity. Evidence of reliability of this scale, as administered to Iranian relevant populations, in this research, by Alpha Coefficient is 0.79 and by Split-half is 0.75. The validity coefficients of questions are between 0.25 and 0.79 and all the validity coefficients are significant at $p < 0.0001$.

2.3 Fatigue scale

This scale is a 14 items questionnaire by Chalder et al. (1993) [31] that measures the physical and mental symptoms of fatigue. It is made based on the frequency of fatigue symptoms that employees have experienced in the past month. Scoring is based on a Likert scale of five degrees from 0 (never) to 4 (very much). A sum of the scores given to items is reported as the total score of fatigue symptoms for a worker. Prior studies surveying many industries and organizations provide evidence for high internal reliability and criterion validity of the scale [32]. Evidence of reliability of this scale, as administered to Iranian relevant populations, in this research, by Alpha Coefficient is 0.88 and by Split-half is 0.83. The validity coefficients of questions are between 0.22 and 0.84 and all the validity coefficients are significant at p <0.0001.

2.4 Work stress scale

Work stress was measured by the Perceived Job Stress Scale (PSS) of Cohen et al. (1983) [33], translated and validated in Persian. PSS is the most widely used psychological instrument for measuring perceived stress. It measures the degree to which situations in one's life are rated as stressful. The items asked respondents how often they found their lives unpredictable, uncontrollable, and overloaded [34]. All the items were modified to ensure that they were appropriate for the industrial context and included several direct questions about the current levels of experienced job stress. A sample item is ''in the last month in the work environment, how often have you been angry because of the things that were outside of your control.'' The PSS was designed in community samples with at least a junior high school education. The items were grasped easily, and the response alternatives were understood simply. Further, the queries are public and thus are relatively free of content specific to any subpopulation group. The questions in the PSS ask about feelings and thoughts during the last month. In each case, respondents are asked about how often they felt in a certain way. Scoring is based on a Likert-scale format from never (0) to very often (4). This scale has validity (reliability = 0.84, 0.85, 0.86 in three cases), high internal reliability (0.79 = Cronbach's Alpha), and acceptable validity [35]. Also, Demir and Orucu (2008) [36] mentioned Cronbach's Alpha of 0.84 and its correlation with the questionnaire "Public Health" 0.61. Exploratory and confirmatory factor analysis of the PSS showed that the scale consisted of two dimensions: Perceived job helplessness factor and perceived job self-efficacy [36]. Internal consistencies (Cronbach's α) in this study, in Iran, for occupational stress, perceived job self-efficacy, and perceived job helplessness were respectively reported at 0.83, 0.75, and 0.87 which was excellent for these scales. The Statistical Package for the Social Sciences (SPSS) version 15 was used to analyze the data. Also, descriptive statistics and stepwise regression analysis were used to summarize, organize, and analyze the data.

3. Results and Discussion

The demographic characteristics of the participants of this study were presented in Table 1.

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

Variable	Group	Frequency	Frequency Percentage
Age	18 to 29 years	49	27.5%
	30 to 41 years	122	67.5%
	42 to 53 years	9	5%
Sex	Male	180	100%
	Woman	-	-
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	-	-
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%
	No shift	50	27.5%

The results showed that there was a significant correlation between work situation awareness (Mean = 64.65, SD = 8.14) with fatigue (Mean = 40.17, SD = 5.51) and work stress (Mean = 37.49, SD = 4.21) ($p < 0.01$).

We used stepwise regression analysis to assess the predictive power of work situation awareness by fatigue and work stress variables. The results of the model summary are presented in Table 2.

Table 2: Summary of the regression analysis model

Variable	R	R^2	ΔR^2	ΔF	Significant
Step 1: work stress	0.35	0.12	0.12	24.82	0.000
Step 2: work stress and fatigue	0.47	0.22	0.09	22.06	0.000

*R: Correlation Coefficient; R^2: R square; ΔR^2: The change in the R-square when a variable is removed from a regression; F: Mean Square Regression.

The results of the regression model for explaining work situation awareness based on fatigue and work stress indicated that F-statistic for both models is significant in $p <$ 0.01. Therefore, there was a possible explanation of work situation awareness based on both variables. Table 3 presents the regression coefficients of stepwise regression analysis.

Table 3: Summary of stepwise regression analysis to predict work situation awareness based on fatigue and work stress

Variable	B	β	SE B	T	R^2	Significant
Work stress	-0.39	-0.45	0.07	-5.82	0.16	0.000
Fatigue	-0.31	-0.54	0.11	-4.70	0.11	0.000

*B: Regression unstandardized coefficient; β : Regression standardized coefficient; SE B: Standard error for the unstandardized beta; t: One-sample *t-test*; R^2: Correlation Coefficient square.

As can be seen, the work stress variable with β = -0.39 can significantly predict almost %16 of the variance of work situation awareness. Also, the fatigue variable with β = -0.31 can significantly predict almost %11 of the variance of work situation awareness. The result of the current research showed fatigue variable significantly predicted work situation awareness among workers. This is consistent with the findings of the previous studies [37-39] and can be interpreted based on the following possibilities: Wallace et al. [37], in their research, concluded that individuals who scored higher on daytime sleepiness and fatigue also experienced more cognitive failures. Fatigue due to sleep disruption in petroleum and chemical industries is part of working and these results show that it is harmful to employees by decreasing their work situation awareness [2]. Loristet al [38] concluded that mental and physical fatigue caused impaired cognitive control and decrease situational awareness. Similarly, McDonald et al. (1993) [39], 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 obvious results of physical and mental fatigue among employees. Therefore, tired workers lose their vigilance and alertness, and consequently cannot pay attention to the workplace conditions. Unfortunately, there were conditions and many factors in the working environment that cause fatigue in individuals. One of these factors is the change in shift workers. Many employees work in a shift pattern (known as 'short change') which includes workers changing halfway through the day-shift to nightshift or vice versa), which results in disrupting sleep patterns and increasing fatigue [40]. Also, workplace 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, and workers also may share an accommodation cabin, which can disturb relaxation time and sleep and increase fatigue among them [28]. Companies and industries can consider altering the shift patterns that are in place to make them more stable. For example, allow employees to always work a day or night shift rather than switch shift patterns in the middle (split/swing shift), or install extra sound insulation in cabins to allow workers to enjoy more undisrupted sleep and thus reduce fatigue among employees [17]. Also, the result of the current research showed work stress variable significantly predicted work situation awareness among workers. This is consistent with the findings of the previous studies [2, 17, 41] and can be interpreted based on the following possibilities: Individuals reporting higher levels of stress were found to have poorer work situation awareness [41]. The literature shows that stress has a tendency to cause persons to narrow their attention [42] and can impair cognitive functions by undermining working memory [43]. High levels of stress can result in poor concentration/alertness as a result of an overload of the person's cognitive resources. Stressors can be physical, such as vibration, crowding, noise, pollution, temperature, and high/low light levels [42, 44], factors which feature predominantly and are nearly unavoidable in the harsh Oil and Gas industrial environment [29, 45]. There can also be psychological stressors, such as anxiety, or social stressors [46]. Concerning situation awareness, researchers report that high stress can interfere with the primary perception of the work situation. The most common effect is the narrowing of the attention 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 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 also self-imposed pressure to complete a work by a certain time [2, 47]. The levels of occupational stress on Oil and Gas industrial installations have been measured in a series of studies and relationships with accident rates established [48].

4. Conclusion

The findings of this research emphasize the importance of fatigue and work-related stress variables in predicting work

situation awareness among workers. Safety intervention needs to focus on these variables, as well as on the prevention methods coping against them. These concepts influence the increase of work situation awareness directly or indirectly. It is recommended that future research examine the effects of safety interventions on increasing situational awareness. Further, by 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 needs more empirical support. Till then, the findings of the study should be interpreted with caution. Further, the cross-sectional design of the study and participants (i.e., a group of employees) exert some limitations on the generalization of the findings. Finally, the problems and limitations of using self-repotting instruments should not be overlooked.

Authors' Contributions

Fariba Kiani: Methodology; Writing-Original draft; Writing-review; Data analyzing. Iman Alavi: Project administration; Editing.

Conflicts of Interest

There are no conflicts of interest.

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