

# Predictive Power of Work Situation Awareness by Work Overload and Job Stress among Workers: Implication for Occupational Health

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## Abstract

**Backgrounds:** Situation awareness is an important factor in industrial accidents. Improving situation awareness may help to prevent occupational accidents. Determination of factors influencing situation awareness will help to plan and take measures for betterment of working condition and development of a safer workplace. In this study, we examined the role of work overload and job stress in predicting work situation awareness among workers.

**Methods:** This is a cross-sectional study. A sample consisting of 180 employees in National Petrochemical Company in 2014 was selected using stratified random sampling method; the participants filled out the questionnaires containing questions on demography characteristics, work situation awareness of Sneddon, Mearns & Flin (2013), work overload of Beehr, Walsh & Taber (1976), and job stress scale of Cohen and colleagues (1983). The data were analyzed by SPSS software using coefficient correlation and stepwise regression. Statistical differences were considered significant at  $P < 0.001$ .

**Results:** The results showed that there were internal correlation among work overload, job stress and work situation awareness. Also, the results of stepwise regression analysis revealed that work overload and job stress significantly predicted, respectively, almost 11% and 35% of variances of work situation awareness among workers.

**Conclusion:** Work overload and job stress are two main factors for predicting work situation awareness. To improve workplace safety, interventional measures should focus on enhancing the situation awareness via workload and job stress reduction.

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## Introduction

One critical element in predicting occupational accidents is the ability of employees to maintain an adequate understanding of their work situation. This means having a high level of awareness of job duties and workplace conditions, and judging how these may change in the

near future to predict how the situation will develop.<sup>1,2</sup> Cognitive psychologists have long been interested in attention,<sup>3</sup> and the role of cognitive skills in safety issues is well documented.<sup>4</sup> In industrial companies, the necessary attentional skills are referred to as 'situation awareness' (SA). SA is defined by Endsley<sup>5</sup> 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". This SA has been further studied in aviation industry;<sup>6</sup> in recent years, many studies have been performed in the fields such as aircraft maintenance,<sup>7</sup> the military,<sup>8</sup> driving,<sup>9</sup> anaesthesia,<sup>10</sup> the maritime industry,<sup>11</sup> and nuclear power plants.<sup>12</sup> Cognitive skills such as work situation awareness are known to be susceptible to the elements of work-related conditions such as work overload and job stress.<sup>13,14</sup>

Unusually high workloads can affect individuals' performance.<sup>15</sup> Work overload was defined by Hart and Staveland<sup>16</sup> as "a hypothetical construct that represents the cost incurred by a human operator to achieve a particular level of performance". If workload is high or the tasks are very complicated, it can mean that workers are involved in attending particular tasks, or are distracted by other pressing issues to tackle, and so do not apportion adequate time to monitor their work situation. In doing so, their situation awareness will be damaged, as they may be unaware of situational changes, and may make improper decisions based on incomplete or incorrect data.<sup>17</sup> Consequently, they may also be unable to react quickly enough should an unforeseen incident occur.<sup>1</sup> Although oil and gas industries try to maintain the correct balance between production pressures and safety,<sup>18</sup> in today's energy market, changing demand is an intrinsic characteristic of the oil working environment and, therefore, work does not always occur at a constant rate. Low workload phases do occur (e.g. waiting on weather), but more typical are periods when workload sharply increases (e.g. due to production pressures, or when the number of workers on workplace is low). Studies indicate that increased workload has a detrimental effect on workers' psychological wellbeing.<sup>19-21</sup> Also, high level of stress can result in reduced working memory capacity and diminished attention.<sup>22</sup> 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, causing inattention to the available information and data in the surrounding environment. Consequently, there may be a narrowing of the individual's attention to incorporate only a number of key aspects in her/his surrounding environment, resulting in peripheral information receiving little or no attention.<sup>1,4</sup> 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.<sup>23</sup> Relatively high levels of work stress have been measured in studies done in the oil and gas industry,<sup>24</sup> and relationships between stress and accident rates have also been established.<sup>25</sup>

With respect to the above mentioned points, the

aim of the current research was to investigate the relationship between work overload and job stress with work situation awareness. So far, little research (particularly in Iran) has been done on work situation awareness and the current research is new.

## Methods

This cross-sectional study was conducted between October and November 2014 at one petrochemical industry in Asalooeyeh area. This area is located on the shore of the Persian Gulf some 270 km SE of the provincial capital of Bushehr and is best known as the site for the land-based facilities of the large Pars Special Energy Economic Zone (PSEEZ) project.<sup>26</sup> In this study, we used stratified random sampling to select the participants. To determine the sample size, a pilot study was carried out in which 50 petrochemical employees participated. Based on the results of the pilot research, with confidence level of 95% and study power of 80%, the sample size was calculated to be 190 workers. Participants in this research were randomly selected from the corresponding personnel list such that workers of important jobs and units (i.e. operation, engineering, security, HSE and fire fighting, maintenance and office work) were included. The inclusion criterion of the employee was at least one year work experience. The exclusion criterion were incomplete questionnaire, the lack of interest in participating in the current research and the history of mental disorder or accidents affecting the musculoskeletal system. Participants were assured that their information will remain confidential. They could withdraw from our study whenever they wanted. 180 completed questionnaires were collected. This study was approved and financially supported by research committee of faculty of psychology and educational sciences of Allameh Tabataba'i University and National Petrochemical Company.

## Measurements

Validated instruments were used for data collection on work situation awareness, work overload and job 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 adjustment of the Persian translation based on direct discussion between the translators. The validity of the questionnaire was tested by consulting experts in this field. Cronbach alpha was calculated (85%, 78% and 77%) to assess the internal consistency of the three questionnaires. Linguistic validation was performed by three experts of psychology department and five experts of safety and health departments. Thus, the questionnaires were piloted and finalized with an advisory group of workers to ensure that the scales' items were

comprehensible and appropriate to the context. Moreover, conceptual analysis confirmed the content validity of all instrument. The questionnaires were distributed among the workers with the help of union steward. The following questionnaires were used:

- **Demographic factors.** Five demographic factors, namely age, marital status, education, years of working experience and shift *status* were included. Marital status was classified as married or not married (including divorced and widowed).

- **Work situation awareness (SA).** SA was measured by 20 items of Sneddon, Mearns, Flin.<sup>27</sup> Respondents indicated the extent of agreement with each statement on a 5-point Likert-type scale (0=very often; 5=never). The questions of this scale consist 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 and colleagues,<sup>27</sup> in their study, calculated the internal reliability of this scale as acceptable (Cronbach's alpha=0.86) and it had a good validity. The reliability of the questionnaire was confirmed by Cronbach's alpha of 0.75. The validity coefficients of the questions were between 0.25 and 0.79; all the validity coefficients were significant at  $P < 0.0001$ .

- **Work Overload.** This scale contained 4 items of Beehr, Walsh and Taber<sup>28</sup> and referred to general perceptions about whether there was work density (eg hours of work) in the job or not. Two samples of the questions of this scale were "I am so busy on the job that I can't take normal breaks" and "There is too much work to do in my job to be done well". Participants showed the extent of agreement with each statement on a 5-point Likert-type scale (1=strongly disagree; 5=strongly agree). Mantineau<sup>29</sup> reported the internal validity of this scale using Cronbach's alpha 0.83. Also, she showed that this scale had a good criterion validity. Internal consistencies (Cronbach's  $\alpha$ ) in this study in Iran were 0.79, which was good for this scale.

- **Work stress scale.** Work stress was measured by Perceived Job Stress Scale (PSS) of Cohen and colleagues,<sup>30</sup> translated and validated in Persian.<sup>31</sup> PSS is the most widely used psychological instrument for measuring the 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.<sup>32</sup> All the items we used were modified to ensure that they were appropriate for the industrial context and included a number of direct questions about the current levels of experienced job stress. A sample item is "in the last month in work environment, how often have you been angry because of the things that were outside of your control?" The

PSS was designed for using 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 of a public nature and thus are relatively free of content specific information about any subpopulation group. The questions in the PSS ask about the perceived stress during the last month. In each case, respondents are asked about how often they felt in a certain way. Scoring was based on a Likert-scale format from never (0) to very often (4). This scale has a reliability of .84, .85, and .86 in three cases, high internal reliability (0.79=Cronbach's Alpha) and an acceptable validity.<sup>33</sup> Also, Demir and Orucu<sup>34</sup>, in their study, mentioned the Cronbach's Alpha 0.84 and its correlation with the questionnaire "Public Health" was 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.<sup>34</sup> Internal consistencies (Cronbach's  $\alpha$ ) in this study, in Iran, for the occupational stress, perceived job self-efficacy and perceived job helplessness was respectively reported 0.83, 0.75 and 0.87 which was excellent for these scales.

After the questionnaires were filled out, data were analyzed using SPSS, version 15. Also, we used descriptive statistics and stepwise regression analysis to analyze the data. The statistical significance level was considered at  $P < 0.001$ .

## Results

Demographic characteristics of the participants of this study are presented in Table 1. In addition, all the participants in this study were male.

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

As can be seen, there were significant relationships among work overload, job stress and work situation awareness ( $P < 0.01$ ).

To assess the predictive power of work situation awareness by work overload and job stress variables, we used stepwise regression analysis. The results of model summary are presented in Table 3.

The results of regression model for explaining work situation awareness based on work overload and job stress indicated that R square for final model is significant in  $p < 0.001$ . Therefore, there was the explanation possible of work situation awareness based on both variables. In Table 4, the regression coefficients of stepwise regression analysis are presented.

As can be seen, job stress variable with  $\beta = -0.69$  can significantly predict almost 35% of the variance of work situation awareness. Also, work overload

**Table 1:** Demographic characteristics of the subjects (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%
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, SD and internal correlation coefficients of research variables

	$\bar{x}$	SD	Correlations		
			1	2	3
1. Work overload	18.39	3.13	1		
2. Job stress	46.72	5.21	0.52**	1	
3. Work situation awareness	64.65	6.25	-0.33**	-0.53**	1

**Table 3:** Summary of regression analysis model

Model	R	RSquare	Adjusted R Square	Std. Error the Estimate	Sig.
1	0.60	0.35	0.35	7.27	0.000

a. Predictor: (constant), Job stress and work overload

**Table 4:** Summary of stepwise regression analysis to predict work situation awareness based on work overload and job stress

Variable	Unstandardized Coefficients		Standardized Coefficients	t	R <sup>2</sup>	Sig.
	B	SE B	$\beta$			
Job stress	-0.49	0.05	-0.69	-9.90	0.35	0.000
Work overload	-0.27	0.06	-0.33	-4.66	0.11	0.000

variable with  $\beta=-0.33$  can significantly predict almost 11% of the variance of work situation awareness.

## Discussion

The results showed work overload significantly predicted work situation awareness among workers. This is consistent with the findings of the previous studies<sup>35-38</sup> and can be interpreted on the basis of the following points. Several studies indicated how the concepts of workload, situation awareness, and safety performance relate to each other for individual operators.<sup>35-40</sup> These models generally indicate that work overload has a negative impact on work situation awareness, which in turn has a positive correlation with incidents among workers. That is, as workload increases, situation awareness decreases and subsequently safety performance worsens.

A Structural Equation Model (SEM)<sup>41</sup> indicates

that the theoretical constructs of SA, workload, and safety performance are related and affect each other, so that the workload negatively affects the SA, a low SA disturbs the safety performance. Also, work overload can result in increasing stress levels among workers that can cause reduced working memory capacity and diminished attention.<sup>42</sup> Work overload can result in poor concentration/alertness due to an overload on the personnel's cognitive resources, and this can interfere with the primary perception of the situation and conditions, causing inattention to the available information.<sup>1,42</sup>

Sawaragi and Murasawa<sup>43</sup> concluded that the high workload of the task demands can affect the decision maker's internal reasoning tasks, and the internal states of the cognitive processing within a decision maker, and that interaction complexity can affect his/her ability of work situation awareness. In another

study, Hancock and Warm<sup>44</sup> show that performance is especially disturbed when a worker is cognitively overloaded. Workers seek to meet task demands but as demands increase, they become overloaded and performance decrements occur. Requiring workers to maintain awareness of their work situation and make efficient decisions while serving long and intense shifts could result in cognitive overload.

Also, the result of the current research showed that job stress significantly predicted work situation awareness among workers. This is consistent with the findings of the previous studies<sup>1,14,45</sup> and this might be due to the fact that individuals reporting higher levels of stress were found to have poorer work situation awareness.<sup>45</sup> The literature shows that stress has a tendency to cause workers to narrow their attention<sup>46</sup> and can impair cognitive functions by undermining working memory.<sup>47</sup> The high level 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,<sup>46-48</sup> the factors which feature predominantly and are nearly unavoidable in the harsh Oil and Gas industrial environment.<sup>25,49</sup> There can also be psychological stressors, such as anxiety, or social stressors (a drilling rig is a small, isolated work environment).<sup>50</sup> In relation to situation awareness, Endsley<sup>46</sup> reports that high stress can interfere with the primary perception of the work situation. The most common effect is narrowing of the attentional field to a restricted number of main elements, whereas data on the periphery is less likely to be encoded. The high level of stress from several directions was 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 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.<sup>1,22</sup> 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.<sup>25,51</sup>

## Conclusion

The findings of this research emphasize the importance of work overload and job stress variables in predicting work situation awareness among workers. Safety intervention needs to focus on these variables, as well as on the prevention methods of coping with them; these concepts influence the increase of work situation awareness directly or indirectly. It is recommended that the future

research examine the effects of safety interventions on increasing situation awareness. Further, with designing these interventions and with more attention to them, we can affect one of the most important influential variables in incidence of occupational accidents. The present study needs to be replicated on 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 on the use of self-reporting instruments should not be overlooked.

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