

A Survey of the Relationship between the Mental Workload and Cognitive Failure in Taxi Drivers, 2017

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Abstract

Background: The mental workload and cognitive failures are among the factors affecting the human behavior, performance and efficiency, which are both effective on the human error and accidents of the drivers. This study was conducted to examine the relationship between cognitive failure and mental workload of taxi drivers in Shiraz.

Methods: This descriptive-analytical and cross-sectional study was conducted on 200 taxi drivers in Shiraz in 2017. In order to measure the mental workload and cognitive failure, NASA-TLX mental workload questionnaire and CFQ cognitive failure questionnaire were used, respectively. Finally, statistical analysis was performed using SPSS version 21. Pearson correlation, T-test and one-way ANOVA tests were used to analyze the data statistically.

Results: The taxi drivers' mental workload was reported relatively high in this study and the results showed that a significant relationship was found between mental and temporal workload and nominal memory error of drivers at 5% error level ($P < 0.05$). Also, a significant relationship was observed between temporal pressure and performance and memory and attention, respectively ($P < 0.05$). In general, a significant relationship was observed between total cognitive failure and total mental workload ($P < 0.05$). Also, demographic factors as age had a significant effect on both mental workload and cognitive failure ($P < 0.05$).

Conclusion: The results of this study showed a significant relationship between the mental workload and cognitive failure, so that with increasing the mental workload, cognitive failure of taxi drivers also increased and the probability of the human error and consequently driving accidents increased. Therefore, reducing the mental workload with providing ergonomic solutions can greatly prevent the human error in driving as a major contributor to many accidents.

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Introduction

The number of deaths of annual road accidents worldwide is estimated 1.2 million persons and the number of injured ones is estimated more than 50 million people. More than 90% of these traffic injuries occur in countries at low

and middle levels.¹ However, in the case of violations of driving rules, many factors such as environmental and executive factors, inappropriate transport structures and the number of vehicles and traffic levels, etc. are involved, but human error as the main factor has the highest percentage as the cause of driving violations.²

Human errors have different causes, but in all cases, the human cognitive ability and constraints play an important role in it. Cognitive failure can be defined as errors on a cognitive basis for performing ordinary and simple tasks that a person can do without mistakes.³ These mistakes may occur at one or all three stages of the processing of memory, attention and action information.⁴

Some of these situations are referred to as cognitive failures, such as the inability to suddenly recall a familiar person or forget him/her. The drivers are prone to cognitive error and unsafe behavior due to the task's cognitive nature.⁵

The existing evidence suggests that a significant relationship is found between cognitive failures and accidents.⁵ Other studies also show a relationship between accidents and distraction, poorly selected attention and mental errors that cause cognitive failures.⁴ A significant correlation was observed between cognitive failure and driving error using simulators. Also, the results of the study by Wickens et al. showed that measures such as cognitive failure and anger can predict errors, mistakes and violent behaviors while driving.⁶

The mental workload is defined as the task needs in terms of difficulty, complexity and temporal pressure, or the effort made to meet the job requirements. Studies have shown that, due to the complexity of the task, the mental workload is high in drivers and one of the factors in accidents is high mental workload.⁷

The mental workload can be considered as an external factor affecting the human mind and cognition, which is influenced by the task and environment, and increasing the cognitive capacities of a person is limited and appear in the form of the human fatigue and error.⁸ On the other hand, cognitive failure is a consequence of the limitations of cognitive capacities and fatigue of the mind.⁹ No study was found on explanation of the relationship between these two categories and examination of the relationship between these two indicators and their aspects with other occupational and personal variables in this occupational group. Therefore, the aim of this study was to examine the relationship between the mental workload and cognitive failure of taxi drivers in Shiraz. A better understanding of the factors affecting cognitive error will certainly be effective on providing preventive strategies.

Materials and Methods

The present cross-sectional study was conducted in 2017 on 200 male taxi drivers in Shiraz who were randomly selected from different parts of Shiraz. In this study, with the confidence level of 95% and estimation precision of 5%, the sample size required was 200 individuals. Data collection tools consisted of a general questionnaire

for collecting background information and two special standardized NASA questionnaires of the mental workload (NASA-TLX) and cognitive failure (CFQ) for assessing the mental workload and cognitive failure, respectively. A brief explanation of the tools used is given below.

NASA-TLX Mental Workload Questionnaire

NASA-TLX Task Load Index is a multidimensional mental workload assessment tool with the aim of assessing and measuring the perceived volume and pressure in order to assess a particular work or activity, system, efficiency, and effectiveness of a team and/or other aspects of performance.¹⁰ The validity and reliability of this questionnaire were reported by Mazlumi et al. (2013), and Cronbach's alpha was estimated $\alpha=0.897$.¹¹

NASA-TLX index has a general score of the mental load, physical labor load, time requirement, performance level, and rate of drowsiness and effort. The score range of NASA-TLX mental workload questionnaire is from zero to 100; the higher the score it represents, the higher the mental workload. This index has more advantages over other workload measurement tools. This method has a high validity and public acceptance and can be used to identify high workload sources.¹²

Cognitive Failure Questionnaire (CFQ)

Broadbent questionnaire of cognitive failures (CFQ) includes 25 questions in four fields of failure in human memory, nominal memory, attention, and exercise.⁴ This questionnaire considers different aspects of cognition, cognitive characteristics, and various theories of cognitive failures, aspects and layers where cognitive failures take place. In the study by Alhayari et al. in order to determine the reliability of this questionnaire, they examined internal consistency and repeatability of this tool in the industrial environment.³ The results of this study showed Cronbach's alpha of this questionnaire as $\alpha=0.96$ which reflects the high reliability of this tool. The score range of the cognitive failure questionnaire is also 0 to 100, and the higher the score, the greater the failure rate. By definition, cognitive failures that are cognitive-based errors occur during a task usually done successfully by a person.¹³

Data Collection and Statistical Analysis

In this study, the questionnaires were filled out face to face. Finally, SPSS21 was used to analyze the data through Pearson correlation, T test and one-way analysis of variance tests.

Results

All participants in this study were male, and their mean

(SD) age and work experience were 39.5 (12.8) and 10.2 (4.2) years, respectively. The demographic information and the main variables of the present study are presented in Table 1. As shown this Table, the age and work experience of the participants were 39.5 (12.8) and 10.2 (4.2) years, respectively. The total workload of the participants was 68 (9.35), and then the performance had a higher score than other aspects of the mental workload. Also, the total score of cognitive failure was 36.35 (13), and attention had the highest score among the cognitive failures.

According to the results shown in Table 2, a significant relationship was observed between the mental pressure and age (P=0.03), temporal pressure and age (P=0.002), effort and age (P=0.02), and mental workload and age (P=0.01). Also, as shown in

Table 1: table1: Demographic characteristics, mental workload and cognitive failure among contributors

Variable	Mean / %	SD
Age	39.5	12.8
Work experience	10.2	4.2
Marital status		
Single	27%	
Married	73%	
Work per day (h)	11.4%	
Accident history in the last year		
Yes	34%	
No	66%	
Mental workload		
Mental pressure	67.2%	16.50
Physical pressure	68.3	18.54
Temporal pressure	70.21	15.71
Effort	72.83	15.41
Performance	76.84	16.97
disappointment	49.84	26.61
Total mental load	68.00	9.35
Cognitive failure aspects		
Nominal memory (1-2)	3.50	1.36
Memory (1-8)	11.00	5.32
Attention (1-9)	15.78	6.51
Action (1-7)	10.00	2.88
Total score (1-100)	36.35	12.97

the other part of this Table, a significant relationship was observed between memory and age (P=0.01), attention and age (P=0.02), attention and history of the accident in the last year (P=0.04), total score of cognitive failure and age (P=0.04), and the total score of cognitive failure and history of the accident in the past year (P=0.03).

Table 3 shows the relationship between workload and cognitive failures in the present study. According to these results, a significant relationship was found between mental pressure and nominal memory (P=0.04), mental pressure and memory (P=0.01), temporal pressure and memory (P=0.001), performance and attention (P=0.03), total mental load and memory (P=0.05), and total mental load and total score of cognitive failure (P=0.05).

Discussion

The factors affecting the performance of drivers and, therefore, their safety are the amount of workload perceived and their cognitive ability to perform a particular task.¹³ Driving is classified as a stressful job, so that stressors create irreparable effects on the drivers' health and increase the human error and consequently driving accident, which is one of the most important causes of death in Iran.¹⁴ Therefore, considering this occupation and the factors causing mental load and its effects on performance can be effective on providing preventive programs. Therefore, the aim of this study was to examine the relationship between perceived mental workload and cognitive failure of taxi drivers in Shiraz.

The perceived mental workload has been obtained 68 among the study subjects, which indicates the high workload of taxi drivers although the total mental workload obtained is less than that of the urban bus drivers, which has been reported in the study by Hasanzadeh Rangi et al.¹⁵ On the other hand, the total score of the cognitive failure in this study

Table 2: Comparison of the aspects of mental workload and cognitive failure between background and demographic variables classified**

Variable	P value					
	Age	Experience	Marital status	Work per day (h)	Accident history in the last year	
Mental workload	Mental pressure	0.03	0.4	0.58	0.3	0.07
	Physical pressure	0.31	0.78	0.28	0.09	0.8
	Temporal pressure	0.002	0.09	0.07	0.34	0.12
	Effort	0.1	0.08	0.76	0.02	0.46
	Performance	0.08	0.24	0.38	0.86	0.72
	disappointment	0.09	0.34	0.54	0.4	0.45
	Total mental load	0.01	0.13	0.3	0.9	0.5
Cognitive failure aspects	Nominal memory	0.07	0.08	0.24	0.72	0.08
	Memory	0.01	0.58	0.76	0.45	0.09
	Attention	0.02	0.38	0.86	0.72	0.04
	Action	0.7	0.3	0.9	0.5	0.24
	CFQ total score	0.04	0.1	0.08	0.76	0.03

** All the relationships were positively significant

Table 3: The relationship between the mental workload and cognitive failures

Cognitive failure	Nominal memory(P)	Memory(P)	Attention(P)	Action(P)	Total score(P)
Mental workload					
Mental pressure	-0.17(0.04)	-0.19(0.01)	-0.002(0.9)	-0.02(0.8)	-0.05(0.6)
Physical pressure	-0.01(0.8)	-0.02(0.6)	-0.11(0.2)	-0.13(0.9)	-0.3(0.9)
Temporal pressure	-0.002(0.99)	-0.26(<0.001)	-0.01(0.91)	-0.03(0.7)	-0.02(0.8)
Effort	0.02(0.6)	-0.07(0.4)	0.008(0.8)	-0.01(0.8)	-0.02(0.9)
Performance	-0.2(0.057)	-0.02(0.06)	-0.17(0.03)	-0.1(0.1)	-0.02(0.08)
Disappointment	0.3(0.09)	0.08(0.3)	0.03(0.1)	0.4(0.08)	0.3(0.09)
Total mental load	0.02(0.9)	-0.03(0.05)	0.05(0.56)	-0.06(0.07)	-0.07(0.05)

was 35, which is higher compared to the study by Hassanzadeh Rangi et al. on urban bus drivers, but less than the values obtained in the studies conducted on the nurses. The differences can be due to the effect of demographic characteristics and occupational stress on cognitive capacities and finally cognitive failure. The most effective aspect of cognitive failure was attention and the least effective aspect was nominal memory. This indicates a reduction in the drivers' attention capacities; given that attention is one of the essential functions of safe driving, considering it and its improvement is essential through necessary changes.¹⁶

On the one hand, age was the only demographic characteristic that showed a significant relationship with total mental workload and aspects of mental pressure and temporal pressure. Although no study has been found on the relationship between age and total mental workload for comparison, this may be due to the reduction of cognitive capacities and the performance of the individual with increase in age. A significant relationship was found between cognitive failure and age as well as the history of the accident in the past year. Therefore, there was a significant relationship among memory, attention and the total score of cognitive deficits and age; also, the memory and total score and the history of the accident during the last year were significantly related. With increased age, cognitive capacities and cognitive failure reduced. On the other hand, similar results were obtained in the studies conducted by Hassanzadeh Rangi and Alahyari, which showed a significant relationship between cognitive failures and unsafe behaviors as well as minor accidents; this indicates the effectiveness of cognitive capacity on driving safety which needs to be taken into account.^{3, 13, 15}

The results of this study showed that there was a significant relationship between total workload and total score of cognitive failure and their aspects, so that the mental workload had a significant relationship with memory and nominal memory, temporal workload had a significant relationship with memory, and performance was significantly related to attention.

According to the results of the correlation between aspects of cognitive failures of driving and some aspects of workload, it can be argued that high

workload directly and through its aspects affects the rate of cognitive failure. Also, Stenfors reported a significant relationship between the quantitative work needs and cognitive failures. Therefore, despite the lack of a direct correlation between workload and cognitive failure, it can be argued that these two components have mutual interactions through their aspects.

Study Limitations

The limitations of this study include using the self-report method to collect the data. In order to overcome this problem and confirm the results of this study, objective methods should be used.

In addition, although this study and previous ones showed a significant relationship between cognitive failures and mental workload, further studies are required to determine the role of mediator factors for better explanation of the relationship and the causes affecting it.

Conclusion

According to the results of the present study, it can be concluded that the perceived mental workload of a taxi driver is high. Therefore, this job requires the adoption of appropriate engineering and management solutions to reduce the workload. In this regard, it is recommended that effective measures should be taken to improve the work conditions of taxi drivers by applying the necessary modifications in each of the six aspects of the mental workload and the implementation of appropriate work programs and managerial control methods for reducing the workload and creating appropriate work conditions that can enhance the drivers' satisfaction and reduce accidents. The direct correlation between work load and cognitive failures can be explained by the fact that these two components have mutual interactions through their aspects. Accordingly, by improving the working conditions that lead to reduced mental workload, we can also reduce cognitive failures. On the other hand, with performing on-the-job tests and selecting the right individuals in terms of cognitive abilities to work in this sector, we can reduce the cognitive failure and accidents caused by it.

Conflict of Interest: None declared.

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