

Fuzzy Factor Analysis on Seamen's Occupational Stressors

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Abstract. As a major guarantee to accomplish safe maritime transportation, seamen's physical and psychological health directly influence the safety of human lives, properties, and marine environments at sea. Excessive occupational stress has an adverse impact on seamen's physiology, psychology and behavior, and may lead to increase in proportion to anthropic factor in maritime casualties. In this article, seamen's working stressors are analyzed based on Fuzzy Factor Analysis, main factors of which are concise and to the point proposed accordingly.

Introduction

Seamen are the major guarantee to the maritime safety transportation, whose physical and psychological health directly concern the safety of human lives, properties, and marine environments at sea. With rapid development of ship and navigation technology, seamen are facing more and more working pressures from professional competition, technical update, safety responsibility, interpersonal relationship, team collaboration etc, which may have bad effects on seamen's physiology, psychology and behavior, and in turn bring about large proportion of human factors in marine accidents. Statistics shows that over 85% of maritime accidents are related to human factors, such as seamen's improper operation and so on, in which fatigue and stress are the key elements of causing human errors^[1]. Alert of Lloyd's Register indicates that human factors take up 66% of marine accidents, most of which are related to seamen's stresses. The stresses increasingly cause for widespread concern by professionals. Which shouldn't be neglected when speak of research on working pressure is that it doesn't mean to eliminate it completely, but to control it within a moderate range. Practices show that appropriate working pressure arouses the enthusiasm, and stimulates innovation and strain capacity of the crew. Therefore, seeking out pressure source with scientific research methods and sorting those impact weights will help seamen maintain an appropriate occupational stress, as well as avoid malignant working stresses which may harm the crew's health and safety sailing at sea.

1. Definition of stress in psychology

In psychology, stress is a process of cognition and behavioral experience consisting of stress source and reaction. Seaman's occupational stress manifests they may have a feeling of tension when influenced by various stimulation factors in the working condition. This tension will affect seaman's behavior from either positive or negative aspects. When under pressure, body itself will instinctively mobilize the potential to cope with various stimulations, therefore, produces a series of physical, psychological and behavioral changes. Appropriate stress helps seaman develop his potential and keep positive working attitude. However, seaman's organism will generate suppression effect if sustained for too long with too much pressure, which may lead to sluggish reaction, in turn cause mis-operation and maritime accidents. As you can see, it is far from eliminating working pressure, but regulating it within a benign and affordable range on pressure source inquiry of the crew.

2. Pressure Source

2.1 Definition of Pressure Source

Pressure source, also known as stressor or tension source, is a factor(or factors) which challenges individual's adaptive capacity and promote generation of pressure reaction.

2.2 Classification of Pressure Source

(1) Biological pressure source, are events which directly blocks and destroys individual's life and race continuation, such as trauma and body disease, hunger, sexual exploitation, sleep deprivation, noise, temperature changes and so on.

(2) Psychic pressure source, are internal and external events which directly hinders and damages individual's normal spiritual needs, such as incorrect cognitive structure, individual's undesirable experience, moral conflict and indecent psychological characteristics from a long tough time.

(3) Pressure source of social environment, are events that directly cause block-ups of social need and destruction of individuals. It can be divided into two parts: one part is pure social, such as significant social transformation, breakdown of important relationship, long-time family conflict, war, being imprisoned and so on; the other is like interpersonal adaptation which results from one's conditions.

3. An indicator system for crew's working stressors

Based on the comprehensive analysis on reasons of crew's working stressors, we consulted relative experts of stress management, specialists of navigation issues, senior crew manager and present crew of shipping enterprise, and concluded an indicator system for crew's working stressors. This indicator system consists of five criteria layers and one index layer formed by 24 index factors. Adopting a combination method of questionnaire and survey on actual ship, we have proceeded sample survey in navigation colleges and universities, port and shipping enterprise, and actual ship, and get a conclusion that this index system corresponds with the practical working situation, which is very representative in universal significance.

Table 1: Indicator System for Crew's Working Stressors

Organization Element(A1)	Minimum Safe Manning(B1)
	Supervision and Management System(B2)
	Interpersonal Relationship on Board (B3)
	Seaman's Duty of Watch Keeping(B4)
Individual Element(A2)	Art of Leadership(B5)
	Professional Skill and Personnel Competence (B6)
	Fatigue and Insomnia(B7)
	Time Management (B8)
	Personality Trait(B9)
	Situational Awareness(B10)
Career Development(A3)	Public Holiday(B11)
	Operational Security(B12)
	Ideal and Reality(B13)
	Role Conflict or Obscureness(B14)
	Impact from Mistake (B15)
Working Environment(A4)	Frustrated Ambition(B16)
	Decision-making participation(B17)
	Harsh Environment(B18)
	Staff Liquidity(B19)
Family Environment(A5)	Technology Refresh(B20)
	Financial Burden(B21)
	Marital Conflict(B22)
	Professional Competition(B23)
	Lack of Family Support(B24)

4. Calculation and analysis of crew's working stressors

It is difficult to quantify crew's working stressors when considering the ambiguity and uncertainty of the their individual feelings. Therefore, Fuzzy Factor Analysis is employed to put forward main factor of crew's working stressors through sequencing weight of Standard and Index layer.

4.1 Theory of fuzzy factor analysis

Factor analysis^[2,3] acknowledge some correlation among impact factors which related to seaman's working stressors. On condition of no loss of major information, some impact factors of complexity relationships are generalized into a small number of common factors. Through calculating, find the loading coefficient 'n' of the common factors, which indicates correlation between impact factor and factors themselves. The larger the loading value is, the more contribution of impact factor is to the common factor. Mathematical model of factor analysis is as follows:

$$\begin{aligned} x_1 &= \alpha_{11}F_1 + \alpha_{12}F_2 + \dots + \alpha_{1p}F_p + \varepsilon_1 \\ x_2 &= \alpha_{21}F_1 + \alpha_{22}F_2 + \dots + \alpha_{2p}F_p + \varepsilon_2 \\ &\dots \\ x_p &= \alpha_{p1}F_1 + \alpha_{p2}F_2 + \dots + \alpha_{pp}F_p + \varepsilon_p \end{aligned} \quad (1)$$

In which: x is a variable, α_{ij} ($i = 1, 2, \dots, p; j = 1, 2, \dots, p$) are specific coefficients (factor loading), F_1, F_2, \dots, F_p are common factors.

Common factors F_1, F_2, \dots, F_p also can be expressed as:

$$\begin{cases} F_1 = b_{11}x_1 + b_{12}x_2 + \dots + b_{1p}x_p \\ F_2 = b_{21}x_1 + b_{22}x_2 + \dots + b_{2p}x_p \\ \dots \\ F_m = b_{m1}x_1 + b_{m2}x_2 + \dots + b_{mp}x_p \end{cases} \quad (2)$$

In which: b_{mp} is score coefficient of the main factors, x_p is the standardized index, p is the index amount, m is the total number of main factors. According to the scores of each main factors, comprehensive value can be calculated as:

$$V = (F_1 \times C_1 + F_2 \times C_2 + \dots + F_m \times C_m) / C \quad (3)$$

In which: C is the accumulative variance, C_m is the variance percentage of each factor.

4.2 Calculations on pressure factors of the crew

Applying fuzzy^[4,5] method to calculate stress factors of the crew, we can get the cause index as follows (Table 2):

4.3 Weight Analysis of crew's stressor elements

We can get some conclusions according to Table 2:

(1) Weight sequence of standard layer A of crew's working stressors is: organization element A1 (2.1213) > career development A3 (1.3473) > individual element A2 (0.8734) > family environment A5 (0.3963) > working environment A4 (0.2617). As you can see, organization element is the main crew's stressor source.

(2) The top five of weight sequence of index layer is: interpersonal relationship on board B3 (5.3486) > ideal and reality B13 (3.3319) > art of leadership B5 (2.6637) > fatigue and insomnia B7 (1.9291) > operational security B12 (1.6971). Apparently, interpersonal relationship is the main factor causing working stress, followed by career development barrier owing to professional particularity as a seaman, the art and level of management of ship's leader, working fatigue and operational security while sailing, all of which bring about pressure to the crew.

The results from the research above is in accordance with the specialist and questionnaire survey of actual ship, which suggests the effective ways to reduce seamen's stressors are as follows: guarantee minimum safe manning, establish scientific management rules and supervision system, promote art of leadership of ship's manager, improve reasonable nutrition diet and assure moderate leisure and entertainment to relieve occupational fatigue. Meanwhile, it is further proves the research corresponds to real work condition of the crew, and it's of high guide significant.

Table 2: Index Computation of Crew's Working Stressors

Standard A Index B	A1	A2	A3	A4	A5	B	Sequence
	2.1213	0.8734	1.3473	0.2617	0.3963	Sequence	Number
B1	0.3119					0.6616	10
B2	0.2107					0.4470	15
B3	2.5214					5.3486	1
B4	0.7003					1.4855	6
B5	1.2557					2.6637	3
B6		0.7234				0.6318	12
B7		2.2087				1.9291	4
B8		0.1912				0.1670	19
B9		0.3215				0.2808	18
B10		1.0145				0.8861	9
B11		0.5407				0.4722	13
B12			1.2596			1.6971	5
B13			2.4730			3.3319	2
B14			0.7002			0.9434	8
B15			0.3454			0.4654	14
B16			0.2218			0.2988	17
B17				2.4379		0.6380	11
B18				0.3247		0.0850	22
B19				0.1789		0.0468	23
B20				0.0585		0.0153	24
B21					1.0274	0.4072	16
B22					2.4478	0.9701	7
B23					0.2367	0.0938	21
B24					0.2881	0.1142	20

References

- [1] Gongchen Liu. Regulation Definitions of the People's Republic of China on Seamen[M]. Beijing: People's Communications Press, 2007.
- [2] Rong Ma, Jiansheng Shi. Fuzzy factor analysis applied in the assessment of groundwater pollution. Journal of Earth Science. Vol.32, No.5, Sep.2011:611-622.
- [3] Yanzhang Su. Comparative study on the application of conventional and fuzzy factor analysis of work pressure source[D]. Xinzhu: National Chiao Tung University, 2001.
- [4] Tan Songlin, Huang Ling, Li Yawei. Application of Fuzzy-AHP Comprehensive Evaluation to the Quality Classification of Wall-Rock in Deep Buried Tunnels. Geological Science and Technology Information, 2009-01.
- [5] Metin Celak, I. Deha Er, A. Fahri Ozok. Application of fuzzy extended AHP methodology on shipping registiy selection: The case of Turkish maritime industry. Expert Systems with Applications. Volume 36, Issue 1, January 2009: 190-198.