Human factors in seafaring: The role of situation awareness

CrossMark

Jose R. Cordon [a,*], José M. Mestre [b], Jorge Walliser [c]

[a] *Universidad de Cádiz-SASEMAR, Cádiz, Spain*
[b] *Universidad de Cádiz, Department of Psychology, Cádiz, Spain*
[c] *Universidad de Cádiz-SASEMAR, Department of Science and Technology of Navigation, Cádiz, Spain*

A R T I C L E I N F O

A B S T R A C T

The main goal was to identify Human Factors in seafaring. First, a group of experts made a list of adjectives. Then, a sample of 141 Officers were asked to give their opinion about the importance of each adjective in Seafarer's behaviour. Exploratory Factor Analysis and Confirmatory Factor Analysis through Structural Equation Modelling techniques were applied to the data. Two factors were identified in aptitudes: "Situation awareness" comprising adjectives from levels 1-2-3 SA; and "adaptability". From attitudes, first component is "Self-Knowledge", component 2 "Group Skills" and component 3 "Drive". Structural Equation Modelling confirmed the factor structure previously found. It can be concluded that: SA would be a key factor in Sea Navigation, there is psychometric evidence of the construct validity; and Human Factors in seafaring can be described using a five-factor model.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

1.1. Human factors in maritime navigation

In 2010, the International Maritime Organization (IMO) pointed out clearly that:

> the key to maintaining a safe shipping environment and keeping our oceans clean lies in all seafarers across the world observing high standards of competence and professionalism in the duties they perform on-board. The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended in 1995 and again in 2010, sets those standards, governs the award of certificates and controls watchkeeping arrangements. Its provisions not only apply to seafarers, but also to ship-owners, training establishments and national maritime administrations.

[IMO, 2010, p. 1]

The latest revisions of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) include for the first time non-technical training aspects such as personal, group and leadership skills. These amendments, known as Manila Amendments (IMO, 2010), are related to: (a) Bridge Resource Management; (b) Engine-room Resource Management (c) Leadership and Managerial Skills, and (d) Application of Leadership and Team-working Skills, require the IMO States Members to implement seafarers training policies not only focused on the technical aspects, but also on the performance in the Navigation Bridge Management and in other duties performed on board.

Previously to the adoption of the so called Manila Amendments, several studies on human factor applied to maritime fields were published. In 1997 Koester (1997) updated several concepts on human factor and its application to seafaring. In subsequent studies, Hetherington et al. (2006), highlighted the importance of the human factor in the field of navigation in relation with maritime safety.

1.2. Situation awareness and sea navigation

Although during the last 20 years SA construct has been mainly applied to the field of aviation rather than to maritime navigation, nevertheless, several studies were carried out in this field.

Grech et al. (2002) analysed a number of accident reports and its relation with the lack of Situation Awareness (SA) in order to determine whether or not SA was a relevant issue in merchant shipping operations. Other authors have studied in depth a number of factors affecting the performance of mariners, noting that SA is a major issue, but considering each component as workload or attention individually (Grech et al., 2008; Koester, 2003, 2007). In addition, Chauvin et al. (2013) demonstrated the applicability of the

construct to risk in manoeuvres during maritime navigation. This study presented a decision making model for ships crossing situations using the Endsley SA three levels approach (1995).

Lately, SA has also been applied to maritime traffic control. In this field several studies have been published. It worth to highlight the studies carried out by Nilsson et al. (2008) who identified factors used by expert VTS operators to get and keep SA in maritime surveillance. Wiersma (2010) who performed a practical use of SA for VTS in the Port of Rotterdam, Van Westrenen and Praetorius (2012) who developed a theoretical approach to maritime traffic control (VTS) using SA construct in and They showed the utility of using SA to asses performance in VTS; similarly, Wiersma (2010) performed a practical use of SA for VTS in the Port of Rotterdam and Cordón et al. (2014) assessed the SA in VTS operators, and performed and validated a psychometric approach of SA.

1.3. Endsley's situation awareness model

SA Endsley's model (1995) describes a three-level decision-making process, starting from perception of the situation (Level 1), comprehension (Level 2) and finally its projection (Level 3). SA construct has been widely adopted by researchers in several areas, such as air traffic control and navigation, power plants, surgery and so forth.

Despite the existence of abundant literature regarding the use of SA in different fields, there is no empirical or psychometric basis to state that it is useful and appropriate in a particular context; hence there is much debate. Recently, Endsley (2015a, 2015b) has pointed out several theoretical issues still remain under discussion. For example, Salmon and Stanton (2012, p. 1) discussed about SA and security, claiming that:

SA has always been a highly contentious concept, with much debate over theories (e.g. Salmon et al., 2008; Stanton, 2010), measures (e.g. Stanton et al., 2006) and even questions over its existence as a valid ergonomics concept.
[Dekker and Hollnagel, 2004; Dekker et al., 2010]

In addition, several authors complained about the lack of theoretical and methodological consensus. Others have pointed out the ubiquity and the illegitimacy of SA (van Winsen et al., 2014). Furthermore, other SA models have appeared: Sensemaking (Klein, 2014), Distributed SA (Stanton et al., 2014) and Situated SA (Chiappe et al., 2015). Those models or paradigms have been discussed by Endsley (2015a, 2015b), who stated:

"On the contrary, pilots invented SA—it was a part of their vocabulary and conceptualization of their world long before any of us got involved in trying to describe it, measure it, or design for it. They would be talking about it (and lamenting

not having it), whether we were doing anything to help them with it or not (see Byrne, 2014)."
[Endsley, 2015a, p. 4]

We agree with this idea and believe that her model is relevant and useful in seafaring. SA is part of people's thinking who deal with complex tasks in the bridge of a vessel, similarly to any aircraft. In fact, although this study is based on Endsley's model, our research provides a new basis to develop or refine those models.

Our working hypothesis is that SA is a factor underlying seafaring and can be applied to the most important Officer's roles, as shown using the Goal-Directed-Task-Analysis (GDTA) (Endsley and Jones, 2012). Table 1 summarizes the main roles for the three levels in Endsley's SA construct/model.

Therefore, we need to define exactly what the characteristics to be assessed are in officers' behaviour and how they should be measured to enforce legislation. Then, the primary goal of this work is to confirm the role of SA on-board and put in some evidence on construct validity in the seafaring context. The second goal is to develop a psychometric model of aptitudes and attitudes that describes seafarers' behaviour (regarding Human Factors in Maritime Navigation). Further relevant relationships between factors will be studied in the following sections.

2. Method

2.1. Participants

A convenience sample of Marine Officers were chosen for this research (N = 141, 109 were males and 32 females). These individuals were required to fill out two questionnaires. Both questionnaires were available online, in Spanish and English so they could be easily filled out by as many people as possible. Finally, most of them, 80%, were filled out in Spanish. Convenience sample was used to find the most heterogeneous population as possible in terms of age and type of experience. Sample size was limited for the difficulties to reach the seafarer's population which most of them were sailing across the world; the sample comprises Officers coming from a wide variety of vessels (from large tankers and bulk-carriers to tugs, research, passenger, ferries, etc. Three participants came from the navy, 13 from the Coast Guard and 115 from Merchant vessels (see Table 2).

2.2. Procedure

First, a group of experts (N = 18; 17 male and 1 female, age M = 54; SD = 7.6) were asked to elaborate two lists of adjectives what they think the desired or best characteristics of an Officer's

Table 1
Examples of perception, comprehension, and projection elements for sea navigation and work management on board.

Domain	Perception	Comprehension	Projection
Sea Navigation	Harbour location	Sea/traffic conditions. Port regulations. Geographical and tidal conditions	Projected course of own vessel and others. Reporting duties
	Traffic on Course	Traffic advises. Traffic in the area. IMO regulations to prevent collisions. Own and others' vessels characteristics	Projected course to ensure security. Predicted dangerous manoeuvers. Radio contact with other vessels/VTS
	Possibility of failure	Availability of external help (e.g. tugs, anchorage areas)	Find alternatives to deal with the failure
	Load status or passengers	Possibility of cargo damage/personal injuries	Efficient navigation, management of meteorological circumstances and characteristics of the vessel
Work Management on Board	Resources available	Type of staff, capacities and abilities related to work	Work assignment both in harbour/sailing
	Motivation	Personal characteristics of the crew, family, salary, ethnic, etc.	Motivational Leadership
	Bureaucracy	Effective time management	Being able to manage properly self and subordinates' time delegating menial jobs

Table 2
Age and job experience (in years) of the sample.

	Min	Max	M	SD
Age	21	71	41.89	13.02
Experience in years	1	46	12.28	10.69

behaviour are, both attitudes and aptitudes. Each adjective was ranged from 1 "not so important" to 7 "extremely important" using a seven-point Likert scale. The selected adjectives had to be representative of the desired officer's global behaviour, both in the bridge and also during their daily work on board of any vessel. The group of experts was selected between experienced seamen (average expertise $M = 15$; $SD = 6.16$; years of navigation) and was supervised by psychologists. The group comprised Harbour Pilots (2), Masters (14) and one Chief Officer, all of them currently working. Adjectives were finally screened using V-Aiken (Penfield and Giacobbi, 2004) score method of agreement index, and the final lists of adjectives were translated into English. English is compulsory for Officers, so it is spoken by seafarers of any nationality.

We define aptitudes (skills) as "a natural ability or talent" ("Collins American Dictionary," n.d.). While in common language, skill only refers to the ability of an individual to properly perform a task, in psychology skill encompasses both cognitive and emotional capabilities and processes, as well as personality characteristics. Also, we define attitudes as "a manner of acting, feeling, or thinking that shows one's disposition, opinion, etc." ("Collins American Dictionary," n.d.). Table 3 points out definitions used for aptitudes and attitudes.

For the second phase of the research two forms were online (both in Spanish and English languages), using Google Drive ("Google Drive," n.d.). The links were sent to any Officer that could

be reached, whether in active or not, by snowball technique. The process of data collection was completely anonymous and no ethical conflicts were in this research.

Finally all data were collected and processed using IBM SPSS V.22 and IBM AMOS V.20.

3. Results

3.1. Aptitudes results

An Exploratory Factor Analysis (EFA) was conducted. First, Sample Adequacy for aptitudes was tested by measuring KMO index, showing a value of 0.88, this can be considered meritorious (Hutcheson and Sofroniou, 1999), and all KMO values for individual items were >0.75, which is well above the acceptable limit of 0.5 (Field, 2013). Bartlett's test of sphericity $\chi 2(55) = 617.14$, $p < 0.001$, thus making it possible factorization. Having considering the sample size, we also examined the diagonal elements of the *anti*-image correlation matrix. For these data, all values are well above 0.7.

A principal component analysis (PCA) was conducted on the 11 items. There was a little difference between the varimax and oblimin solutions. Thus, both solutions were examined in the subsequent analyses before deciding on an oblimin rotation for the final solution. An initial analysis was run to obtain eigenvalues for each component. Two components had eigenvalues over Kaiser's criterion of 1 and in combination explained 55.40% of the variance, the first factor revealed explained 45.92% and second 9.49%. The scree plot was clear and showed inflexions that would justify retaining 2 components. Given the sample adequacy and the convergence of the scree plot and Kaiser's criterion on two components, this was the number of components that were retained in the final analysis. Table 4 shows the factor loadings after rotation.

Table 3
Definitions of each single aptitude and attitude for Likert scale.

	Definition in the item as...
Aptitude	
Adaptation to life on board	To be able to cope with uprooting and the life on board a ship
Spatial aptitude	To have a good spatial and geometrical sense of direction
Attention	To remain focused on what is important, despite distractors
Technical skills	To handle easily technical elements
Organized	To be tidy and neat with your work; to meet deadlines and targets
Awareness	To keep the overall awareness of the situation, even with overload
Decision	To make successful decisions quickly, even taking few data
Stress.	To be able to cope with stress. To be able to work under pressure
Communication skills	To be fluent in English. To have a good command of nautical language. To express properly
Leadership	To have ability to lead groups and give precise orders
Endurance	Physical strength, resistance to Sleep, etc.
Attitude	
Ambition	To be willing to improve. To seek for excellence
Self-control	Self-control is the ability to control one's emotions, behaviour and desires
Empathy	To be able to understand another person's feelings, emotions and attitudes. To be able to put in another person's shoes
Compliance	To follow the rules, correctly wear the uniform, hygiene, scheduling, security, etc.
Willingness to learn	To be willing to learn new things
Flexibility	To be able to adapt to new environments, new partners, etc.
Initiative	Ability to devise or to take action
Enterprise integration	To integrate culture and philosophy of the company, to share their values
Motivation	Beyond the wage, to be predisposed towards work.
Responsibility	Ability to engagement or care of a person with himself and everything around
Certainty	To be confident to make decisions, self-assured, self-confidence
Tenacity	Firmness, stubbornness and perseverance to accomplish a goal
Tolerance	To deal with others, other cultures, languages, opinions, etc.
Teamwork	To engage the teamwork, ability to integrate in a group
Tranquillity	To be calm, serene

Note: The term "awareness" appears in the list, but it is given in a wider framework, not restricted to navigation context.

Table 4
Factor loadings after rotation for aptitude items (oblimin).

	Component	
	1	2
Spatial aptitude	0.83	−0.32
Technical skills	0.82	
Awareness	0.71	
Leadership	0.71	
Organized	0.65	
Decision	0.65	
Attention	0.62	
Communication skills	0.38	0.33
Adaptation to life on board		0.86
Endurance		0.61
Stress	0.40	0.46

Note: Factor loadings <0.3 have been suppressed.

The items that cluster on the same components suggest that component 1 represents 'Situation Awareness' and component 2 'Adaptability'.

A Confirmatory Factor Analysis (CFA) was performed developing a model in IBM AMOS V.20 using factors found in EFA. All items were compulsory in the questionnaire, so there were no missing data. SEM model shows very good fit $\chi2$ (19, N = 141) = 19.23, p = 0.44, TLI = 0.99, suggesting that the proposed model is consistent with the observed data. Due to the sample size, we also looked at CMIN/DF = 1.01 (chi square/degree of freedom ratio). Different researchers (Marsh and Hocevar, 1988) have recommended using a ratio as low as 2 or as high as 5 to indicate a reasonable fit. CFI = 0.99 (comparative fix index), close to 1 indicates a very good fit, >0.9 or close to 0.95 indicates good fit. By convention, CFI should be equal to or >0.90 to accept the model, CFI is independent of sample size. NNFI = 0.99 (non-normed fit index, TLI or RHO2), Bentler (1999) and Marsh et al. (2004) supported the continued use of TLI because it is relatively insensitive to sample size, sensitive to model misspecifications, relatively insensitive to violations of assumptions of multivariate normality,; and relatively insensitive to the estimation method (maximum likelihood vs alternative methods). RMSEA = 0.009 (root mean square error of approximation); the RMSEA values are classified into four categories: close fit (0.00–0.05), fair fit (0.05–0.08), mediocre fit (0.08–0.10), and poor fit (over 0.10) (Marsh et al., 2004). PCLOSE = 0.779 tests the null hypothesis that RMSEA is no >0.05. If PCLOSE is <0.05, we reject the null hypothesis and conclude that the computed RMSEA is >0.05, indicating lack of a close fit. Adaptation to Life on Board, Communication Skills and Technical Skills dropped from the final model, due to their low loadings. Fig. 1 represents SEM model for aptitudes.

As a value of internal consistency, Cronbach's alpha was α = 0.87, and for factor 1 α = 0.86 and for factor 2 α = 0.66 respectively, showing high and medium reliability, probably due to the number of items on second factor.

Some analysis of variance was performed, looking for any relations between factors and variables. Several ANOVA showed that importance given to SA or Adaptability were not significantly different by age or gender. Post hoc analyses using the Scheffé post hoc criterion for significance indicated that the importance given to Stress was significantly higher in the female group (M = 6.31, SD = 0.693) than in the male condition (M = 5.95, SD = 0.961), F (1, 139) = 4.043, p = 0.046, η^2 = 0.97. No more significant relationships were found.

3.2. Attitudes results

A principal component analysis (PCA) was conducted on the 11 items with orthogonal rotation (varimax). The Kaiser–Meyer–Olkin measure verified the sampling adequacy for the analysis, KMO = 0.87 (almost 'superb' according to Field, 2013), and all
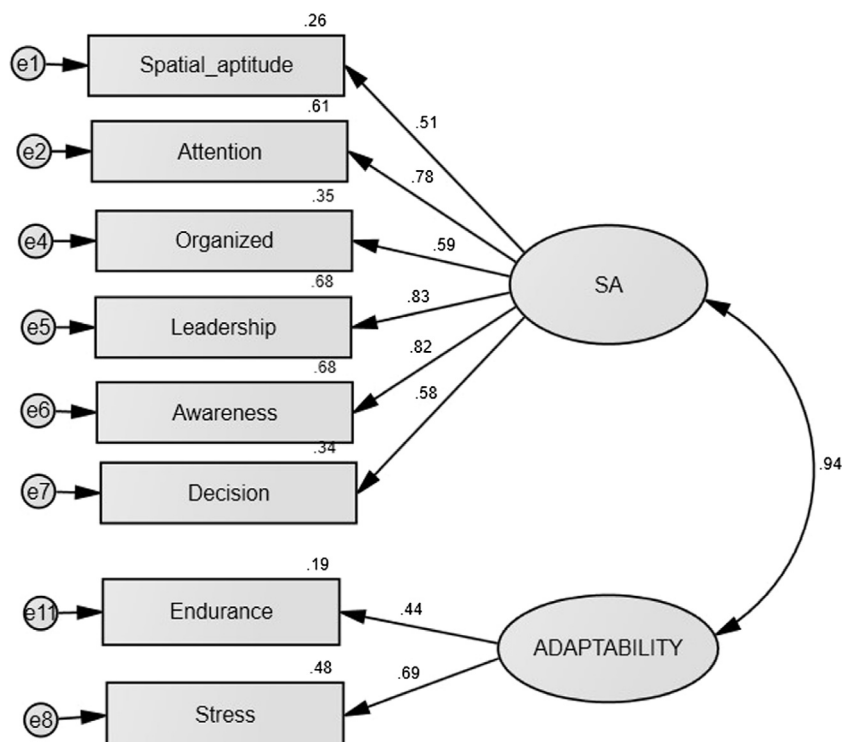

Fig. 1. SEM model for aptitudes.

Table 5
Factor loadings after rotation (varimax).

	Component		
	1	2	3
Certainty	0.92		
Self-control	0.71		
Tenacity	0.65		
Responsibility	0.64		
Initiative	0.62		
Tranquillity	0.61		
Tolerance		0.79	
Flexibility		0.79	
Empathy		0.77	
Teamwork		0.56	
Willingness learn		0.54	0.37
Enterprise integration			0.82
Ambition			0.70
Motivation	0.31		0.59
Compliance		0.31	0.47

Note: Factor loadings <0.3 were suppressed.

KMO values for individual items were >0.75, which is well above the acceptable limit of 0.5 (Field, 2013). Bartlett's test of sphericity $\chi2(105) = 93$, $p < 0.001$, indicated that correlations between items were sufficiently large for PCA. An initial analysis was run to obtain eigenvalues for each component. Three components had eigenvalues over Kaiser's criterion of 1 and in combination explained 59.77% of the variance. The scree plot showed inflexions that would justify retaining three components. Given the convergence of the scree plot and Kaiser's criterion on three components, this is the number of components that were retained in the final analysis. Table 5 shows the factor loadings after rotation.

The items that cluster on the same components suggest that component 1 represents 'Self-Knowledge', component 2 'Group Skills', and component 3 'Drive'.

A CFA was performed developing a model in IBM AMOS V.20 using factors found in EFA. SEM model shows good fit $\chi2$ (24, N = 140) = 29.59, $p < 0.199$, TLI = 0.98, suggesting that the proposed model is consistent with the observed data. Values of indexes are CMIN/DF = 1.233, CFI = 0.98, NNFI = 0.98, RMSEA = 0.04, and PCLOSE = 0.59. Finally, Certainty, Tenacity and Tranquillity dropped from the first factor; Tolerance and Willingness to learn, from the second; and Motivation, from the last. Fig. 2 represents SEM model for attitudes.

As a value of internal consistency, overall Cronbach's alpha was $\alpha = 0.891$, for factor 1 (0.85), 2 (0.82), 3(0.73) and 4(0.69), respectively showing high to medium reliability in all scales, depending on the number of items.

Some ANOVA were performed. Post hoc analyses using the Scheffé post hoc criterion for significance indicated that the importance given to Responsibility was significantly higher in the female group (M = 6.54, SD = 0.665) than in the male condition (M = 6.23, SD = 0.846), F(1,139) = 4.942, $p = 0.028$, $\eta^2 = 0.96$. Also, the importance given to Tenacity was significantly higher in the female group (M = 6.25, SD = 0.718) than in the male condition (M = 5.88, SD = 0.930), F(1,139) = 4.316, $p = 0.040$, $\eta^2 = 0.96$. No more significant relationships were found.

4. Discussion

Our working hypothesis was that the construct SA is a factor underlying in seafaring, taking into account all the literature regarding this particular. Both, PCA and SEM analysis are highly consistent with this hypothesis; despite the sample size, psychometric precautions have been taken so this point does not affect the results. The main limitation of this research is that the sample might be biased because most of the participants were from the same country. Some language limitations must be considered, although the questionnaires were developed in parallel both in
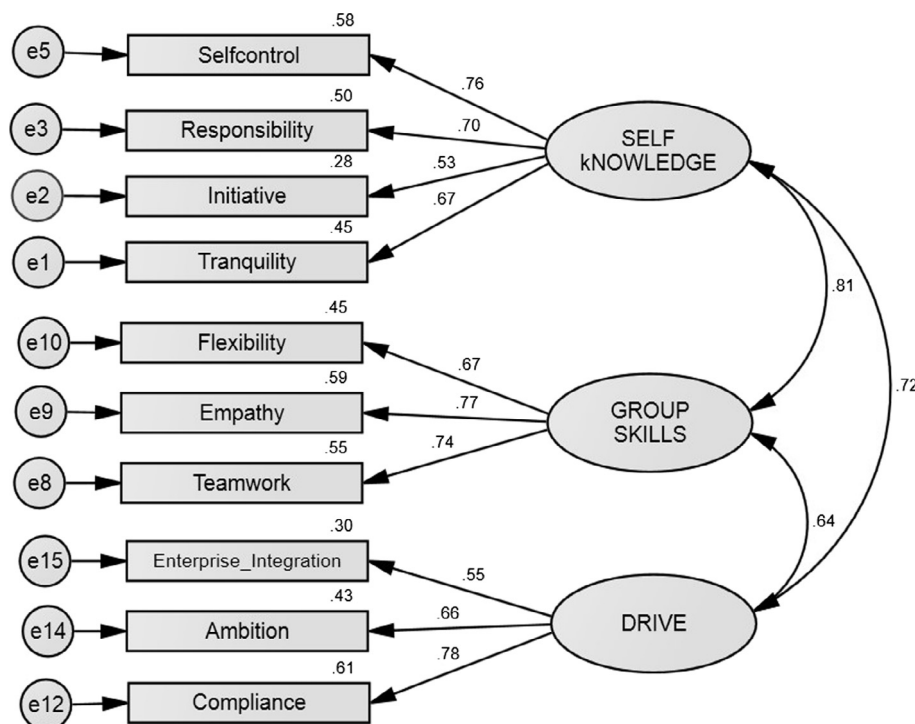

Fig. 2. SEM model for attitudes.

Spanish and English, the participants had the freedom to choose which one to answer.

4.1. Aptitudes model

Following Ensley's model, we can interpret the EFA results as Spatial Aptitude and Attention, Level 1 SA: perception, in the wheelhouse the main source of information is visual, by naked eye or by radar. Technical Skills and Organized as level 2 SA, comprehension, were the officer-on-watch has to make up all the information acquired in level 1 with previous knowledge, both technical about navigation and organizational and bureaucracy issues. Awareness, Decision and Leadership as level 3 SA, projection; Awareness in the sense of global overview, and Decision and Leadership meaning willpower and ability to make decisions. Factor loadings in CFA give some points about the main characteristics on sea navigation. The higher loading is for Leadership, following by Awareness and Attention; however, Communication Skills and Technical Skills were dropped, as their contribution to the final model was not significant. Model draws clearly how the first factor is composed by attention and spatial attitude (level 1 SA), organized and decision (level 2 SA) and awareness and leadership becomes level 3 SA. This model is highly consistent with the data as can be seen, but is also coherent with the perception of an Officer's behaviour on duty.

Second Factor that came out from Aptitudes is Adaptability and comprises Endurance, Communication, Stress Coping and Adaptation to life on board. Finally, adaptation to life on board was taken out from the final model. This Factor, Adaptability explains 9.4% of variance. SEM model also shows that there is high relationship between both factors, this can be interpreted as poor discriminant validity between factors or the existence of another factor of second order. Taking into account that the first factor explains almost 55% of variance, in fact, we can suspect that we are dealing with a single construct structure, but this can be expected if we are trying to understand Officers' behaviour on board; and that was the question we asked the participants. We can interpret that dealing with stress and endurance (second factor descriptive) is really part of the SA model; as a cognitive, dynamic construct, SA embodies not only elements of perception, memory and decision, but mechanisms to facilitate these processes.

4.2. Attitudes model

Three Factors came out from the EFA: Group Skills that comprises tolerance, empathy, teamwork, flexibility, and Willingness to learn. Self-Knowledge, with initiative, certainty, self-control, tenacity, responsibility and tranquillity. Drive comprises ambition and compliance, adjustment to Rules, motivation and enterprise integration.

SEM model has excellent fit as well as aptitudes. Some interesting points could be highlighted: Certainty, Tenacity and Tranquillity were taken out from the first factor; Tolerance and Willingness to learn from the second and Motivation from the last; however, these three factors can be interpreted the same way, so they really were not so relevant for the model. These three factors answer the question what is the desired attitude of an Officer. The Seafarer must have a good understanding of himself as a person, knowing his limitations and handling his emotions. He must also be able to handle groups of people, motivate, understand, and know how to work with their personal, with ethnic and cultural differences, using the best characteristics of their crew. Finally, he must be motivated enough to be able to adapt to the Shipping Company's particulars, understanding its characteristics and what

is expected from him, and have enough ambition to reach the goal of every officer that is to command a vessel. SEM model has excellent fit and enough simplicity to put in some psychometric evidence on human factors in Seafaring. These findings are highly consistent with those pointed by M. Grech et al. (2008) and Hetherington et al. (2006).

4.3. Other findings

Non-significant differences were found according to professional qualifications, either Masters with a lot of experience or cadets, Chief Mate or others have very closer point of view regarding what is important in Officers' behaviour. There were some significant differences according to sex, despite the few women that took part in the research, anyhow it reflects the reality in Seafaring were women are still a minority. Women give more importance to tenacity, responsibility and stress handling than men. Perhaps the perception of these concepts is different because this is a profession traditionally for men and only in the last twenty years is incorporating women to ships. "Glass ceiling" effect do women foresee that they have to be tougher to achieve their goals in a profession dominated by men.

As for the importance given to control stress it could be for reasons of coexistence in a group where they often find themselves isolated and sometimes there may be discrimination, but also the uprooting play a greater role in this group. It would require a more detailed investigation into these aspects.

The base hypothesis of this research is that SA is a factor underlying in seafaring. Therefore, we try to find whether Endsley's conception of SA for pilots stands, but applied to Seamen. In our opinion, the evidence is consistent with Endsley's model. SA is not an idealistic construct just for researchers, Seafarers understand the meaning and the importance of the whole process, from attention through comprehension to projection, and they know that the most important thing to do in the bridge is to keep the complete process working. Nevertheless, not only in Sea Watch, SA has implications in work organization and other tasks for the Officers in accordance with the GDTA developed in Table 1, and the psychometric model agree with this idea as well. Our findings are highly consistent with those researchers who pointed out that SA is a valid framework to explain human behaviour in complex situations with overload and decision-making process, particularly with those related to aviation (because of the similar environment) such as Endsley's. Albeit some researchers still hesitate about using this model (or any similar) we found that this concept really exist in this context and is a solid foundation for further researches.

The second goal was to put the spotlight on Human Factors in Seafaring: what really makes an Officer a good Officer? We find five factors (2 emerging from aptitudes and 3 from attitudes) explaining the keys for selection, training and education, with impact in security and efficiency in Sea Transportation, in line with the suggestions given by IMO as well as on Universities, Ship-owners and Governments. Future research should be directed to explain in depth these factors and develop recommendations, curricula, and training and assessment systems to future Officers.

The main limitation of this research is the nationality of the most part of the participants; however the breadth of experience of the participants can deal with this shortcoming thus, the participant experience covers practically any type of vessel, so the sample is not biased by this variable. We encourage researchers from another countries, cultures and languages to extent this investigation to support this model with greater generalizability.

Appendix A

Adjectives for Seafarers

In this questionnaire you will find (listed alphabetically) several questions related to your job. You are kindly required to answer each of them choosing the answer that best reflects the degree of agreement to each of the keywords. The values range from 1 (not so important) to 7 (extremely important). There is no right or wrong answers. Your appreciation will be very useful to improve the working conditions of your workplace.

* indicates compulsory question.

Thank you very much for your feedback.

Statistical Data

In this part we ask you some details for statistical purposes. The whole procedure is protected by the Spanish Privacy Act and is very confidential. We are not interested in who you are. We only need to know your opinion and your level of expertise.

Sex
Age
Which Certificate do you hold?
Expertise *
How many years have you been enlisted as Master, Officer or Cadet?
Expertise *
Brief description of your professional expertise

Skills or Aptitudes

A natural ability or talent.

While in common language skill only refers to the ability of an individual to properly perform a task, in psychology skill encompasses both cognitive and emotional capabilities and processes and personality characteristics.

Here is a list of adjectives that can define the main competencies that a Master or Officer must have. We

ask you to assess your level of agreement with each of the keywords. The values range from 1 (not so important) to 7 (extremely important).

At the end of the questionnaire, you could suggest any other adjective that we have not included.

Adaptation to life on board *
To be able to cope with uprooting and the life onboard a ship
1 2 3 4 5 6 7
Spatial aptitude *
To have a good spatial and geometrical sense of direction
1 2 3 4 5 6 7
Attention *
To remain focused on what is important, despite the distractors
1 2 3 4 5 6 7
Technical skills *
To handle easily technical elements
1 2 3 4 5 6 7
Organized *
To be tidy and neat with your work, To meet deadlines and targets
1 2 3 4 5 6 7
Awareness *

To keep the overall awareness of the situation, even with overload
1 2 3 4 5 6 7
Decision *
To make successful decisions quickly, even taking few data.
1 2 3 4 5 6 7
Stress. *
To be able to cope with stress. To are able to work under pressure.
1 2 3 4 5 6 7
Communication skills *
To be fluent in English. To have a good command of nautical language. To express properly.
1 2 3 4 5 6 7
Leadership *
To have ability to lead groups and give precise orders
1 2 3 4 5 6 7
Endurance *
Physical strength, resistance to Sleep etc.
1 2 3 4 5 6 7
Now you can add any adjective you miss.

Attitudes

Attitude is a manner of acting, feeling, or thinking that shows one's disposition, opinion, etc.
As before, we ask you to assess your level of agreement with each of the keywords. The values range from 1 (not so important) to 7 (extremely important).
At the end of the questionnaire, you could suggest any other adjective that we have not included.

Ambition *
To be willing to improve. To seek for excellence.
1 2 3 4 5 6 7
Self-control *
Self-control is the ability to control one's emotions, behavior and desires.
1 2 3 4 5 6 7
Empathy. *
To be able to understand another person's feelings, emotions and attitudes. To be able to put in another person's shoes.
1 2 3 4 5 6 7
Compliance *
To follow the rules; correctly wear the uniform, hygiene, scheduling, security, etc.
1 2 3 4 5 6 7
Willingness to learn *
To be willing to learn new things.
1 2 3 4 5 6 7
Flexibility *
To be able to adapt to new environments, new partners, etc.
1 2 3 4 5 6 7
Initiative *
Ability to devise or to take action
1 2 3 4 5 6 7
Enterprise Integration *
To integrate culture and philosophy of the company, to share their values

1 2 3 4 5 6 7
Motivation *
Beyond the wage, to be predisposed towards work
1 2 3 4 5 6 7
Responsibility *
Ability to engagement or care of a person with himself and everything around
1 2 3 4 5 6 7
Certainty *
To be confident to make decisions, self-assured, self-confidence
1 2 3 4 5 6 7
Tenacity *
Firmness, stubbornness and perseverance to accomplish a goal
1 2 3 4 5 6 7
Tolerance *
with others, other cultures, languages, opinions, etc.
1 2 3 4 5 6 7
Teamwork *
Engages the teamwork, ability to integrate in a group
1 2 3 4 5 6 7
Tranquility *
To stay calm, serene.
1 2 3 4 5 6 7
If you want, You can add any adjective you think is important and is not in the list.

References

Bentler, P.M., 1999. Structural equation modeling with small samples: test statistics. Multivar. Behav. Res. 34 (2), 181–197.

Byrne, E., 2014. Commentary on Endsley's "Situation awareness misconceptions and misunderstandings". J. Cogn. Eng. Decis. Mak. 9 (1), 84–86. http://dx.doi.org/10.1177/1555343414554703.

Chauvin, C., Lardjane, S., Morel, G., Clostermann, J.P., Langard, B., 2013. Human and organisational factors in maritime accidents: analysis of collisions at sea using the HFACS. Accid. Anal. Prev. 59, 26–37.

Chiappe, D., Strybel, T.Z., Vu, K.-P.L., 2015. A situated approach to the understanding of dynamic situations. J. Cogn. Eng. Decis. Mak. 9 (1), 33–43. http://dx.doi.org/10.1177/1555343414559053.

Collins American Dictionary, n.d. <http://www.collinsdictionary.com/dictionary/american> (retrieved May 5, 2015).

Cordón, J.R., Ramiro Olivier, P., García Sedeño, M., Walliser Martín, J., 2014. Diseño y validación de una prueba de selección para controladores de tráfico marítimo basada en la medida de la conciencia situacional. J. Work Org. Psychol. 30 (2), 83–93. http://dx.doi.org/10.1016/j.rpto.2014.06.002.

Dekker, S., Hollnagel, E., 2004. Human factors and folk models. Cogn. Technol. Work 6 (2), 79–86.

Dekker, S.W.A., Hummerdal, D.H., Smith, K., 2010. Situation awareness: some remaining questions. Theor. Iss. Ergon. Sci. 11 (1–2), 131–135. http://dx.doi.org/10.1080/14639220903010092.

Endsley, M.R., 1995. Toward a theory of situation awareness in dynamic systems: situation awareness. Hum. Factors 37 (1), 32–64. http://dx.doi.org/10.1518/001872095779049543.

Endsley, M.R., 2015a. Final reflections: situation awareness models and measures. J. Cogn. Eng. Decis. Mak. 9, 101–111. http://dx.doi.org/10.1177/1555343415573911.

Endsley, M.R., 2015b. Situation awareness misconceptions and misunderstandings. J. Cogn. Eng. Decis. Mak. 9, 4–32. http://dx.doi.org/10.1177/1555343415572631.

Endsley, M.R., Jones, D.G., 2012. Designing for Situation Awareness: An Approach to Human-Centered Design. Taylor & Francis, London.

Field, A., 2013. Discovering Statistics using IBM SPSS Statistics. Sage.

Google Drive, n.d. <http://www.google.com/intl/es/drive/apps.html> (retrieved January 24, 2014).

Grech, M., Horberry, T., Koester, T., 2008. Human Factors in the Maritime Domain. CRC Press.

Grech, M.R., Horberry, T., Smith, A., 2002. Human Error in Maritime Operations: Analyses of Accident Reports using the Leximancer Tool.

Hetherington, C., Flin, R., Mearns, K., 2006. Safety in shipping: the human element. J. Saf. Res. 37 (4), 401–411. http://dx.doi.org/10.1016/j.jsr.2006.04.007. <http://www.abdn.ac.uk/iprc/documents/safety_in_shipping.pdf>.

Hutcheson, G.D., Sofroniou, N., 1999. The Multivariate Social Scientist: Introductory Statistics using Generalized Linear Models. Sage.

IMO, 2010. Guía STCW para la gente de mar.

Klein, G., 2014. Whose fallacies? J. Cogn. Eng. Decis. Mak. 9 (1), 55–58. http://dx.doi.org/10.1177/1555343414551827.

Koester, T., 1997. Human Factors and Everyday Routine in the Maritime Work Domain, (Salvendy).

Koester, T., 2003. Situation awareness and situation dependent behaviour adjustment in the maritime work domain. In: Proceedings of HCI International, Crete, Greece.

Koester, T., 2007. Terminology Work in Maritime Human Factors. Situations and Socio-technical Systems. Frydenlund.

Marsh, H.W., Hau, K.-T., Wen, Z., 2004. In search of golden rules: Comment on hypothesis-testing approaches to setting cutoff values for fit indexes and dangers in overgeneralizing Hu and Bentler's (1999) findings. Struct. Equat. Model. 11 (3), 320–341.

Marsh, H.W., Hocevar, D., 1988. A new, more powerful approach to multitrait-multimethod analyses: application of second-order confirmatory factor analysis. J. Appl. Psychol. 73 (1), 107.

Nilsson, M., Van Laere, J., Ziemke, T., 2008. Extracting rules from expert operators to support situation awareness in maritime surveillance. In: 11th International Conference on Information Fusion (2008), pp. 908–915.

Penfield, R.D., Giacobbi Jr., Peter R., 2004. Applying a score confidence interval to Aiken's item content-relevance index. Meas. Phys. Educ. Exerc. Sci. 8 (4), 213–225.

Salmon, P.M., Stanton, N.A., 2012. Situation awareness and safety: contribution or confusion? Situation awareness and safety editorial. Saf. Sci. 56, 1–5. http://dx.doi.org/10.1016/j.ssci.2012.10.011.

Salmon, P.M., Stanton, N.A., Walker, G.H., Baber, C., Jenkins, D.P., McMaster, R., Young, M.S., 2008. What really is going on? Review of situation awareness models for individuals and teams. Theor. Iss. Ergon. Sci. 9 (4), 297–323. http://dx.doi.org/10.1080/14639220701561775.

Stanton, N.A., 2010. Situation awareness: where have we been, where are we now and where are we going? Theor. Iss. Ergon. Sci. 11 (1–2), 1–6. http://dx.doi.org/10.1080/14639220903009870.

Stanton, N.A., Salmon, P.M., Walker, G.H., 2014. Let the reader decide: a paradigm shift for situation awareness in sociotechnical systems. J. Cogn. Eng. Decis. Mak. http://dx.doi.org/10.1177/1555343414552297.

Stanton, N.A., Stewart, R., Harris, D., Houghton, R.J., Baber, C., McMaster, R., Ellipsis Green, D., 2006. Distributed situation awareness in dynamic systems:

theoretical development and application of an ergonomics methodology. Ergonomics 49 (12–13), 1288–1311. Retrieved from <http://hdl.handle.net/2438/1419>.

Van Westrenen, F., Praetorius, G., 2012. Situation awareness and maritime traffic: having awareness or being in control? Theor. Iss. Ergon. Sci. 15 (2), 161–180. http://dx.doi.org/10.1080/1463922X.2012.698661.

Van Winsen, R., Henriqson, E., Schuler, B., Dekker, S.W.A., 2014. Situation awareness: some conditions of possibility. Theor. Iss. Ergon. Sci. (October), 1–16 http://dx.doi.org/10.1080/1463922X.2014.880529.

Wiersma, J.W.F.D.U. of T., 2010. Assessing Vessel Traffic Service Operator Situation Awareness. Delft. <repository.tudelft.nl/assets/uuid.../Wiersma_J.W.F._PhD_Thesis.pdf>.