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An explanatory model of underwater adaptation

Joaquín Colodro[1,2*], Enrique J. Garcés-de-los-Fayos[2], Juan J. López-García[2], and Lucía Colodro-Conde[2,3]

[1] Delegación de Defensa en la Región de Murcia (España).
[2] Campus de Excelencia Internacional Regional "Campus Mare Nostrum", Universidad de Murcia (España).
[3] QIMR Berghofer Medical Research Institute (Australia).

Título: Un modelo explicativo de la adaptación subacuática.
Resumen: El medio subacuático constituye un entorno extremo que exige un proceso de adaptación humana con demandas psicofisiológicas específicas para garantizar la supervivencia y la actividad productiva. En este trabajo explicativo se analiza, bajo la óptica de los actuales modelos de inteligencia, personalidad y rendimiento, la contribución de las diferencias individuales para explicar la adaptación de personal militar en un entorno estresante. Se verifica, mediante análisis de ecuaciones estructurales, un modelo donde se contemplan los efectos directos de las variables psicológicas sobre la adaptación personal a un medio adverso, comprobando sus relaciones estructurales durante la realización de cursos básicos de buceo militar y su capacidad para predecir un tercio de la varianza de un criterio poco estudiado. De esta manera, se confirma en una muestra de profesionales (N = 575) la relación directa de ajuste emocional, responsabilidad y habilidad mental general con la adaptación subacuática, atribuyendo una relación inversa a reactividad emocional. Estos constructos constituyen el fundamento psicológico para desenvolverse con seguridad y trabajar bajo el agua, contribuyen a la mejora de la adaptación al medio subacuático y favorecen la prevención de riesgos y la seguridad en las actividades de buceo.
Palabras clave: diferencias individuales; buceo militar; modelos psicológicos; análisis de ecuaciones estructurales; adaptación subacuática.

Abstract: The underwater environment is an extreme environment that requires a process of human adaptation with specific psychophysiological demands to ensure survival and productive activity. From the standpoint of existing models of intelligence, personality and performance, in this explanatory study we have analyzed the contribution of individual differences in explaining the adaptation of military personnel in a stressful environment. Structural equation analysis was employed to verify a model representing the direct effects of psychological variables on individual adaptation to an adverse environment, and we have been able to confirm, during basic military diving courses, the structural relationships among these variables and their ability to predict a third of the variance of a criterion that has been studied very little to date. In this way, we have confirmed in a sample of professionals (N = 575) the direct relationship of emotional adjustment, conscientiousness and general mental ability with underwater adaptation, as well as the inverse relationship of emotional reactivity. These constructs are the psychological basis for working under water, contributing to an improved adaptation to this environment and promoting risk prevention and safety in diving activities.
Key words: individual differences; military diving; psychological models; structural equation analysis; underwater adaptation.

Introduction

The underwater environment is an adverse environment with specific physical and psychological demands, which sometimes results in extreme situations and always requires a process of human adaptation to ensure survival and to realize activities under water (CBA, 2000; Joiner, 2001; U.S. Navy, 2008). Professional divers must have the capabilities to adapt to the unusual features of this adverse environment, modifying the psychophysiological mechanisms that are useful on the surface of the earth and handling specialist technical diving equipment. The aim is to be able to remain under water, to prevent aquatic incidents or dysbaric complications and to carry out a useful and efficient activity in an extreme environment (Bachrach & Egstrom, 1987; Brubakk & Neuman, 2003; Gallar, 1995; NATO, 2000; Rieben & Miller, 2000).

From a physiological perspective and to ensure survival, divers employ mechanisms of cardiovascular and respiratory adaptation, such as bradycardia, peripheral arterial vasoconstriction, active breathing or metabolic and biochemical modifications, which are favored by the use of adequate breathable mixtures and the training of the respiratory function (Broadhurst, Morrison, Howsare, & Rocca, 2005; Tetzlaff & Thorsen, 2005; Vorosmarti & Vann, 1997). On the other hand, to cope with the demands of this hostile environment and to make the most of their available personal resources, divers develop processes of psychological adaptation, such as emotional control, management of the levels of anxiety and stress, or respiratory work regulation. These are complemented with the assessment of psychological fitness and training in risk prevention procedures (Bachrach & Egstrom, 1987; Biersner, 1984; Colodro, 2011). The study of these processes leads to traditional lines of applied research and clinical intervention in underwater and submarine psychology (Colodro, 2012; Daniel, 2006). These include the detection of significant variables in underwater adaptation and the identification of the relationships of divers' dispositional traits with their performance and adaptation to the underwater environment. The goal is to provide data on the role that psychological characteristics can play in the diving training programs and the safety of underwater activities (Colodro, Garcés de los Fayos, & Velandrino, 2012; Morgan, Raglin, & O'Connor, 2004; Van Wijk, 2002; Van Wijk & Waters, 2001). This paper examines the specific contribution of intelligence and personality measures in explaining adaptation in the stressful and uncertain environment under water.

The interest in individual differences is not a recent or specific topic of applied psychology. However, it was not until a few decades ago that it was possible to verify that psychological characteristics have temporary stability and situational consistency and they could be used as predictors of human performance or behavior (Caspi, Roberts, & Shiner, 2005; Schaie, 1996). The intelligence (Horn & McArdle, 2007; McGrew & Wendling, 2010) and personality (Costa & McCrae, 1995; John, Nauman, & Soto, 2008) models provide

*** Dirección para correspondencia [Correspondence address]:**
Joaquín Colodro Plaza. Grupo de Investigación Psicología del Deporte. Universidad de Murcia, 30100 Murcia (España).
E-mail: jcplaza@um.es

a basis for the identification of significant psychological variables in any professional activity, using the dimensions of the general performance model as criteria (Campbell, McCloy, Oppler, & Sager, 1993; Pulakos, Arad, Donovan, & Plamondon, 2000). The importance of intellectual ability in predicting job performance has been tested in civil and military fields, and has been proved to be the best predictor when analyzing training effectiveness or global job performance (Gottfredson, 2002; Ones, Viswesvaran, & Dilchert, 2005a; Ree, Earles, & Teachout, 1994; Salgado et al., 2003; Schmidt & Hunter, 2004). In parallel, the less predictive capacity of personality traits has been verified, although their validity increases when the performance is estimated in terms of other important components of the work (effort, discipline, teamwork, etc.) and theoretically contingent traits are used (Barrick & Mount, 2005; Barrick, Mount, & Judge, 2001; Hogan & Holland, 2003; Hough & Furnham, 2003; Ones, Viswesvaran, & Dilchert, 2005b; Salgado, 1997, 1998; Salgado & De Fruyt, 2005). The development of a general performance model has also contributed to the understanding of the role of dispositional traits and their use in industrial and organizational fields (Schmitt, Cortina, Ingerick, & Wiechmann, 2003).

The involvement of individual differences in underwater adaptation, taking into account the current models of intelligence (Cattell-Horn-Carroll model) and personality (Five Factor model), has been poorly studied compared to other applied areas. The capacity for learning and problem solving, making the right decision, the accurate judgment of situations and the ability to adapt to new environments and situations are important facets in diving which represent the prevailing concept of general intelligence (Gottfredson, 1997, 2002). In addition, divers should be able to perform effectively in stressful and emergency conditions, coping with them with calmness, confidence, security and emotional stability, without being easily affected by the risk, or vulnerable to stress. Conversely, divers must have sufficient emotional control to enable the development of appropriate responses to the environmental conditions and the psychophysiological determinants of an immersion and, simultaneously, to avoid errors or high levels of risk (Bachrach & Egstrom, 1987; Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007; Beckett & Kordick, 2007; Staal, 2004). From the perspective of the general performance model, professional divers should be able to, on the one hand, dive with scuba equipment, use pneumatic and hydraulic tools, inspect and repair damage in the hull and machinery of ships, check safety standards, aid in diving accidents, and manage hyperbaric chambers. These performance dimensions represent skills and competencies which include critical thinking, judgment and decision making, problem analysis and time distribution, oral and written comprehension, deductive and inductive reasoning, selective attention, spatial orientation, static and dynamic strength, manual dexterity, and multiple coordination. On the other hand, divers must be able to cope with emergencies and environmental stressors, undergo uncertain and unpredictable situations, and apply specific technologies and procedures that require psychological characteristics, such as emotional control, management of anxiety and stress, responsibility, autonomy, and capacity of effort, enabling adaptation to the conditions of the underwater environment (Colodro, 2012; Martinez & Lemaire, 1992).

From the point of view of their practical application in this environment, individual differences have been shown to have a relationship to the criteria of diving training, and a psychological profile considered functional in adapting to underwater environment has been defined (Bachrach et al., 1976; Biersner, 1944; Biersner & Larocco, 1983; Moray, Ross, & Synodinos, 1979; Nevo & Breitstein, 1999; Van Wijk, 2002; Van Wijk & Waters, 2001). Intellectual and personality traits allow us to predict significantly the performance obtained in diving courses (Biersner & Larocco, 1987; Edmonds, 1972), while the physical variables contribute to the same objective (Hogan & Hogan, 1985).

On the other hand, according to methodological criteria, the studies of individual differences in intelligence and personality have been historically developed separately as independent domains, without an integrative research line being formed for their study, despite the historical contributions of R.B. Cattell, J.P. Guilford and H.J. Eysenck (DeYoung, 2011). There have been recent attempts at the analysis of the joint forecast of intelligence and personality (Ackerman & Beier, 2003; Austin et al., 2002), verifying that the combination of cognitive and non-cognitive measures can increase the validity in explaining part of the variance in academic or job performance that is not adequately explained by the best measures of intelligence or personality considered separately (Barrick & Mount, 2000; Chamorro-Premuzic, Furnham, & Ackerman, 2006; Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007; Schmidt & Hunter, 2000).

Keeping in mind the psychophysiological demands of the underwater environment, the psychological theories about individual differences, and the methodological criteria referred to in the preceding paragraphs, we attempt to analyze jointly the relationship between intelligence and personality variables and underwater adaptation using a psychometric and correlational approach. More specifically, we aim to clarify the structure and effects of psychological variables in human adaptation to the underwater environment. We analyze the covariance between observed and latent variables using factor analysis and structural equation techniques, in order to contribute to the elucidation of the role of these variables in relation to a criterion rarely referred to in the study of individual differences. In previous studies with samples of Spanish divers, the specific traits of those who attain different levels of underwater adaptation and performance in diving courses have been identified; the relationship of personality and attitudinal factors with performance and adaptation in the underwater environment has been quantified; the usefulness of individual differences in predicting the capacity to adapt to the underwater environment and in anticipating the possibility of higher or lower performance in diving activities

has been determined; and the psychological components of underwater adaptation have been analyzed (Colodro, 1994, 2012; Colodro, Garcés de los Fayos, & López-García, 2013; Colodro et al., 2012). These findings show that there is a specific psychological profile of the military diver, characterized by higher levels in intellectual ability, emotional stability, emotional control and facilitating anxiety and lower levels in emotional sensitivity, insecurity, tension and inhibiting anxiety. These distinctive traits can be considered significant structural factors, based on data from the exploratory and confirmatory factor analysis. In addition, they have the capacity to predict 30% of the variance in underwater performance and make it possible to predict the degree of adaptation in this environment, on the basis of data obtained by multiple linear and logistic regression models.

Hypothetical model

The psychological model of underwater adaptation proposed in this paper is theoretically justified by intelligence, personality and performance models, and also has empirical justification in the diving field. Indeed, based on meta-analyses on the prevailing psychological models of individual differences (Costa & McCrae, 1995; Horn & McArdle, 2007; John et al., 2008; McGrew & Wendling, 2010), three variables with greater explanatory power of human behavior and performance are identified. General mental ability (Gottfredson, 2002; Hunter & Hunter, 1984; Ones et al., 2005a; Ree & Earles, 1992; Ree et al., 1994; Salgado et al., 2003; Schmidt & Hunter, 1998, 2004) and the dimensions of conscientiousness and emotional stability (Barrick & Mount, 1991, 2003, 2005; Barrick et al., 2001; Hogan & Holland, 2003; Hough & Furnham, 2003; Hurtz & Donovan, 2000; Ones et al., 2005b; Salgado, 1997, 1998, 2004; Salgado & De Fruyt, 2005; Tett, Jackson, & Rothstein, 1991) are the best predictors in the civil and military fields.

In light of this, we start from a theoretical model which predicts the existence of three explanatory latent variables, general mental ability, conscientiousness and emotional stability, with a low correlation among them, as indicated by the factorial validity of personality measures (Cattell, 1998) and the relationships of intelligence and personality (Ackerman & Heggestad, 1997; Mount, Barrick, & Strauss, 1999; Schmidt & Hunter, 2000). Therefore the analysis is initially limited to the identification of the direct effects of these latent variables on underwater adaptation. First, general mental ability facilitates the learning of underwater principles as well as the techniques and procedures in this environment, contributing to the realization of the fundamental tasks for underwater work and to the adaptation to a new environment (Bachrach et al., 1976; Biersner, 1984). Secondly, the dimension of emotional stability facilitates the application of appropriate techniques of coping with environmental demands and unexpected or emergency situations that can occur under water, promoting adaptation and performance by allowing the diver to focus on the task to be performed (Bachrach et al., 1976; Biersner & Larocco, 1987; Edmonds, 1972; Moray et al., 1979). Thirdly, conscientiousness favors effort at work because this factor improves the motivation of professional achievement and facilitates survival and personal protection through paying attention to the rules and safety standards for the practice of underwater activities (Biersner & Larocco, 1983; Hogan & Lesser, 1996; Van Wijk, 2002; Van Wijk & Waters, 2001).

When considering the psychophysiological demands of the underwater environment (Bachrach & Egstrom, 1987; Brubakk & Neuman, 2003; CBA, 2000; Gallar, 1995; Joiner, 2001; NATO, 2000; Rieben & Miller, 2000; U.S. Navy, 2008) and the anxiety and stress processes (Bachrach & Egstrom, 1987; Bar-Haim et al., 2007; Beckett & Kordick, 2007; Lazarus & Folman, 1984; Staal, 2004), the dimension of emotional reactivity is integrated into the proposed model. This is consistent with the empirical evidence on psychological profiles of the diver (Bachrach et al., 1976; Biersner, 1944; Biersner & Larocco, 1983; Moray et al., 1979; Nevo & Breitstein, 1999; Van Wijk, 2002; Van Wijk & Waters, 2001), the differential profiles of Spanish divers (Colodro, 1994, 2012; Colodro et al., 2012, 2013) and the validity of the measures of psychological variables in the prediction of underwater adaptation (Colodro, Garcés de los Fayos, López-García, & Colodro-Conde, 2014), which are issued under the prism of the adaptive performance model (Campbell et al., 1993; Pulakos et al., 2000). Thus, we have transformed the initial theoretical model into a hypothetical model, consisting of general mental ability, emotional adjustment, conscientiousness and emotional reactivity as exogenous latent variables, with the relationships shown in Figure 1. As well as being justified by empirical data, these hypotheses are based on the fact that diving is an activity that often requires the solving of problems and incidents and the mastering of specific techniques for working in an unnatural environment. In addition, to acquire underwater adaptation, divers must cope with stressful situations, apply self-control, manage anxiety, act responsibly in an unusual environment and utilize the available resources in the necessary time.

Hence, this paper proposes a structural model where the direct effects of the psychological variables involved in personal adaptation to an adverse environment, with the specific demands of military diving, are analyzed. Based on the evidence and previous data, a direct relationship of emotional adjustment, conscientiousness and general mental ability with underwater adaptation is proposed, an inverse relationship being attributed to emotional reactivity. Psychological adaptation in diving may be an exceptional criterion for verifying the validity of the current psychological theories and models of intelligence, personality and performance.

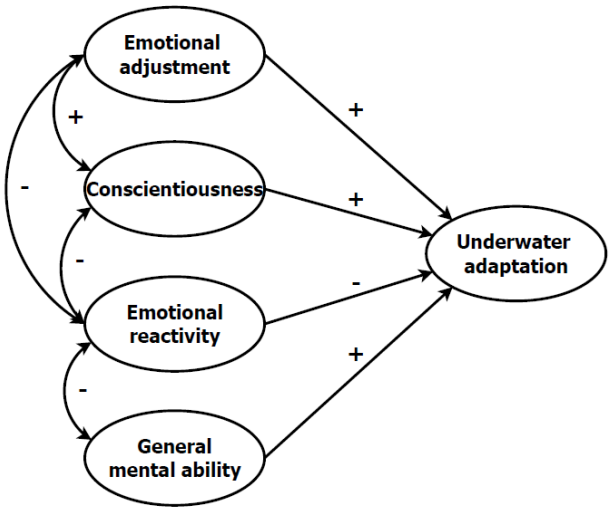

Figure 1. Hypothetical model of underwater adaptation.

Method

Participants

The sample consisted of staff from the Spanish Armed Forces and Security Forces of the State who carried out Elementary Diver courses in the Spanish Navy Diving Center between 1999 and 2008 (N = 575). They are adult Spanish men (M = 28.22; SD = 2.94) with the following academic training: basic level (Primary studies and Intermediate vocational education: 20%), intermediate-level (High School, Higher vocational education and University entrance exams: 40%) and higher level (University degrees: 40%). They have a similar distribution in professional level and military rank (Troop and Seamen: 27%; Non-commissioned officers: 34% and Officers: 39%). The participants belonged to the Spanish Navy (48%), Army (29%), Air Force (5%), Civil Guard (11%) and National Police Corps (7%).

The content and practical development of the basic 8-week diving course carried out by these professionals is aimed at ensuring the safe practice of hyperbaric air diving and underwater activities up to 50 m deep. This training enables them to plan and perform dives with autonomous equipment, maintaining adaptation to the underwater environment, and to carry out tasks related to the safety of persons, ships and naval installations.

Instruments and variables

A battery of psychological tests is applied to candidates wishing to perform diving courses in the Spanish Navy Diving Center, which commonly include the intelligence and personality tests used in this study.

The Test of General Intelligence TIG-2 (Cordero, Seisdedos, González, & de la Cruz, 1994) assesses general mental ability and core functions of intelligence through symbolic material without cultural content. It requires a medium or higher intellectual level to solve the 50 problems proposed by dominoes, following the principles of the g factor tests. The manual indicates high reliability (α = .90), and our research obtained a similar sample value (α = .86).

The 16PF questionnaire of Cattell (1998) evaluates sixteen personality primary factors of a bipolar nature. Its scales have adequate indexes of temporal consistency and equivalency between their parallel forms (Cattell, Eber, & Tatsuoka, 1988; Seisdedos, 1992). The reliability values have been confirmed in Spanish divers, where internal consistency coefficients have been obtained (.60 $\leq \alpha <$ .70) with acceptable values, bearing in mind the number of items that compose the scales (Colodro et al., 2014).

The Facilitating and Inhibiting Anxiety questionnaire is a test of 50 items taken from the Motivation and Anxiety of Execution (MAE) questionnaire by Pelechano (1975), for the evaluation of anxiety processes in military divers. The scales of the questionnaire indicate the components of anxiety that facilitate or inhibit performance, and they have appropriate Spearman-Brown coefficients (r_{11} = .81 and .88) for facilitating anxiety and inhibiting anxiety. The internal consistency coefficients (α = .74 and .83) had an acceptable magnitude in military divers (Colodro et al., 2014).

The estimators of the exogenous variables used in this study (general mental ability, emotional adjustment, conscientiousness and emotional reactivity) were intelligence, personality and anxiety factors assessed with the instruments described in the preceding paragraphs. On the one hand, emotional stability (C), compliance (G), emotional sensitivity (I), insecurity (O), self-control (Q_3), stress (Q_4), facilitating anxiety (FA) and inhibiting anxiety (IA) were used as observed variables of personality. On the other hand, general intelligence (g) and reasoning (B) were the intellectual type estimators.

The estimators of the endogenous variable (underwater adaptation) were the final average grade (FAG) and the order of completion (OC) in the diving course. The FAG is the weighted average of the weekly results in the theoretical and practical aspects of the course (theoretical exams, physical training and diving exercises, with a global weighting of 0.5, 2.5 and 7.0, respectively). The OC is a standardized typical score obtained as a function of the distribution of the grades, taking into account the size of each course (which varied between 15 and 30 divers) and the possible evaluation tendencies of different diving teachers and instructors. Both indicators represent the official result of the training at the Spanish Diving School and estimate the underwater adaptation achieved by divers in undertaking the theoretical, physical and operational demands of the underwater environment.

Procedure

The psychological tests were collectively applied at the beginning of each Elementary Diver course, highlighting in the instructions the usefulness of psychological evaluation

for prevention in the diving field, its use in personal counseling and the confidentiality of the data.

This paper analyzed the variables of intelligence, personality and anxiety obtained through psychological tests, the demographic data and the grades recorded at the Spanish Diving School. The methodology for the data acquisition complied with the guidelines of the Armed Forces Psychology Service Regulations and the psychological code of ethics.

This is an explanatory study with latent variables, following the classification of the research designs of Ato, López and Benavente (2013). It proposes a causal model in which the dispositional traits may explain part of the variance of human adaptation in the underwater environment. Although the fit of a model of latent variables to empirical data does not prove the existence of causal relationships (MacCallum & Austin, 2000; Verdugo, Crespo, Badía, & Arias, 2008), it can at least provide evidence about their functional relationship to human adaptation in diving.

Data Analysis

Firstly, a statistical descriptive analysis (Table 1) was performed, in order to know the distribution of our measures and to check the accuracy and precision of the data.

Table 1. Correlations, means and standard deviations of the variables included in the model.

	g	B	C	O	Q_4	IA	G	Q_3	I	*M*	*SD*
g	---									28.15	5.48
B	.37***	---								9.28	1.86
C	.17***	.08	---							2.90	3.50
O	-.11*	-.01	-.60***	---						7.04	3.19
Q_4	-.04	.03	-.67***	.63***	---					5.02	3.52
IA	-.11*	-.05	-.50***	.52***	.53***	---				2.72	2.63
G	.05	.01	.21***	-.24***	-.31***	-.16***	---			15.86	2.38
Q_3	.02	-.01	.33***	-.31***	-.43***	-.26***	.41***	---		14.63	2.58
I	-.28***	-.15***	-.14**	.09*	.07	.07	-.11*	-.15***	---	7.18	3.09
FA	.15**	.15***	.12**	-.06	-.06	-.05	.09*	.16***	-.24***	13.09	3.51

Note. g = General intelligence; B = Reasoning; C = Stability; O = Insecurity; Q_4 = Tension; IA = Inhibiting anxiety; G = Conformity; Q_3 = Self-control; I = Sensitivity; FA = Facilitating anxiety.
*p<.05, **p<.01, ***p<.001.

Although there is no definitive criterion regarding the number of subjects required to apply the Structural Equation Model (SEM), a sample 10 times greater than the number of variables and a minimum of 200 are recommended to provide sufficient statistical power in the data analysis. Both of these criteria are met in our study (Hair, Anderson, Tatham, & Black, 2004).

Subsequently, a causal model of military diving adaptation was proposed. We contrasted an initial model based on the literature review and previous works and we evaluated its goodness of fit to the empirical data in order to understand the covariance between the observable and latent variables in relation to dispositional traits and underwater adaptation criteria. As usual (Verdugo et al., 2008), the SEM methodology was carried out in five phases aimed at the identification, estimation, modification, verification and re-specification of the model, obtaining a measurement model associated with the confirmatory factor analysis (CFA) and a structural model (SEM). The parameters were estimated with the maximum likelihood method and the model fit was verified through different significance tests (χ^2, χ^2/df, $\Delta\chi^2$) and absolute fit indices, which assess the model's capacity to reproduce the covariance matrix. Incremental fit indices were also used to assess whether the proposed model outperforms the independence model (Hair et al., 2004; Hooper, Coughlan, & Mullen, 2008).

Data analysis was performed using SPSS 19.0 and Amos 7.0 software (Arbuckle, 2006; SPSS, 2010).

Results

According to the exploratory analysis, the variables of intelligence, personality and anxiety had distributions compatible with normality, except for Q_4 and IA which were logarithmically transformed. The absence of violations and the significance of the parameter estimates were verified with SEM methodology. We analyzed the multivariate normality and detected the extreme cases based on Mahalanobis distances. The models were over-identified and recursive.

Before analyzing the structural model, we evaluated the studied indicators, estimated constructs and the goodness of the measurement model using CFA. We analyzed the reliability, factorial validity and significance of each indicator, the joint reliability and variance extracted from each latent variable and the goodness of fit of the measurement model. In this process of analysis, 3 indicators of the initial theoretical model (impulsivity, vigilance and imagination) were replaced in the modified model (with emotional sensitivity, facilitating anxiety and inhibiting anxiety). In addition, the number of constructs increased in the hypothetical model, finally comprising 10 indicators and 4 latent variables (emotional adjustment: C, O, Q_4, IA; conscientiousness: G, Q_3; emotional reactivity: I, FA; general mental ability: g, B). The replacement of indicators and the increase in the latent variables were based on our previous empirical data, the relevance of personality factors in the stress process, the estimated factorial solutions and the overall fit of the measurement model.

The CFA results are outlined in Figure 2. They indicate that self-control has a higher factor loading (λ = .76, R^2 = .58, p < .001) than conformity (λ = .53, R^2 = .28, p < .001) in conscientiousness. Emotional adjustment is defined by 4 indicators, whose standardized regression weights and determination coefficients had the following values: tension (λ = -.85, R^2 = .68, p < .001), stability (λ = .79, R^2 = .64, p < .001), insecurity (λ = -.75, R^2 = .60, p < .001) and inhibiting anxiety (λ = -.64, R^2 = .46, p < .001). Emotional reactivity was composed of factor loadings of sensitivity (λ = .60, R^2 = .27, p < .001) and facilitating anxiety (λ = .41, R^2 = .19, p < .001). Lastly, general intelligence presented a higher factor loading (λ = .80, R^2 = .52, p < .001) than reasoning (λ = .46, R^2 = .24, p < .001) in general mental ability.

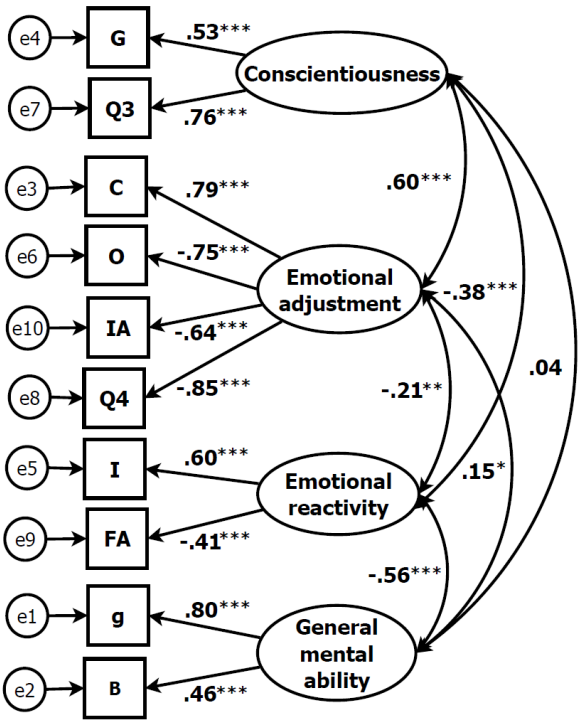

Figure 2. Confirmatory factor analysis. Measurement model. G = Conformity; Q_3 = Self-control; C = Stability; O = Insecurity; IA = Inhibiting anxiety; Q_4 = Tension; I = Sensitivity; FA = Facilitating anxiety; g = General intelligence; B = Reasoning.
$^{*}p$<.05, $^{**}p$<.01, $^{***}p$<.001.

Most indicators had adequate reliability and validity. Meanwhile, the latent variables of the hypothetical model, with the exception of emotional reactivity, showed acceptable values (Hair et al., 2004) in composite reliability (CR > .50) and exceeded the threshold of convergent validity (average variance extracted, AVE > .40). The correlation of the latent variables, validity and composite reliability data are summarized in Table 2, with CR = .75 and AVE = .60 being obtained for underwater adaptation.

Table 2. Reliability and validity of the measurement model.

	EA	C	ER	GMA	CR
Emotional adjustment (EA)	.58				.84
Conscientiousness (C)	.60***	.48			.63
Emotional reactivity (ER)	-.21**	-.38***	.26		-.41
General mental ability (GMA)	.15*	.04	-.56***	.43	.56

Note. The correlations are on the lower triangle of the matrix and the average variance extracted (AVE) on the diagonal. CR = Composite reliability.
$^{*}p$<.05, $^{**}p$<.01, $^{***}p$<.001.

Consequently, the data analysis of the reliability and validity of the indicators and the latent variables is the basis for confirming an adequate fit of the measurement model used, as shown in the significance tests, $\chi^2(29)$ = 47.55, p = .016, absolute fit indexes (*GFI, AGFI, RMSEA*) and incremental fit indexes (*NFI, TLI, CFI*) reflected in Table 3. These findings verify that the indicators used to explain the latent variables of our model are suitable (Hair et al., 2004; Hooper et al., 2008; Hu & Bentler, 1999). They also confirm a significant change, $\chi^2(1)$ = 35.95, p = .001, in favor of the hypothetical model presented in this paper.

The analysis of the structural model fit, outlined in Figure 3 with its standardized coefficients and associated probability, begins with absolute fit measures, assessing their statistical significance and determining the extent to which the model adequately reproduces the relationships existing in the covariance matrix of empirical data (Arbuckle, 2006). With a value of $\chi^2(41)$ = 53.80, p = .087 the null hypothesis is accepted, thus it is established that there are no significant differences between the estimated final model and the available empirical data, confirmed by other complementary fit indexes as summarized in Table 4.

Table 3. Measurement model fit indexes.

Model	χ^2	*gl*	χ^2/gl	*GFI*	*AGFI*	*RMSEA*	*NFI*	*TLI*	*CFI*	$\Delta\chi^2$
Teorethical	169.73***	32	5.30	.94	.90	.09	.87	.85	.89	
Modified	83.50***	32	2.61	.97	.95	.05	.94	.95	.96	86.23***
Hypothetical	47.55*	29	1.64	.98	.97	.04	.96	.98	.99	35.95***

Note. Measurement models: Theoretical (Emotional adjustment: C, L ,O ,Q_4; Conscientiousness: F, G, M, Q_3; General mental ability: g, B), Modified (Emotional adjustment: C, I, O, Q_4, FA, IA; Conscientiousness: G, Q_3; General mental ability: g, B) and Hypothetical (Emotional adjustment: C, O, Q_4, IA; Conscientiousness: G, Q_3; Emotional reactivity: I, FA; General mental ability: g, B).
df = degrees of freedom; χ^2/df = normalized chi-squared; *GFI* = Goodness of Fit Index; *AGFI* = Adjusted Goodness of Fit Index; *RMSEA* = Root Mean Square Error of Approximation; *NFI* = Normed Fit Index; *TLI* = Tucker-Lewis Index; *CFI* = Comparative Fit Index; $\Delta\chi^2$ = chi-square change.
$^{*}p$<.05, $^{***}p$<.001.

Table 4. Structural model fit indexes.

Model	χ^2	*gl*	χ^2/gl	*GFI*	*AGFI*	*RMSEA*	*NFI*	*TLI*	*CFI*	R^2	$\Delta\chi^2$
Hypotetical	75.71**	44	1.72	.98	.96	.04	.96	.97	.98	.39	
Final	53.80	41	1.31	.98	.97	.02	.97	.99	.99	.34	21.91***

Note. df = degrees of freedom; χ^2/df = normalized chi-squared; *GFI* = Goodness of Fit Index; *AGFI* = Adjusted Goodness of Fit Index; *RMSEA* = Root Mean Square Error of Approximation; *NFI* = Normed Fit Index; *TLI* = Tucker-Lewis Index; *CFI* = Comparative Fit Index; $\Delta\chi^2$ = chi-square change. $^{**}p<.01$, $^{***}p<.001$.

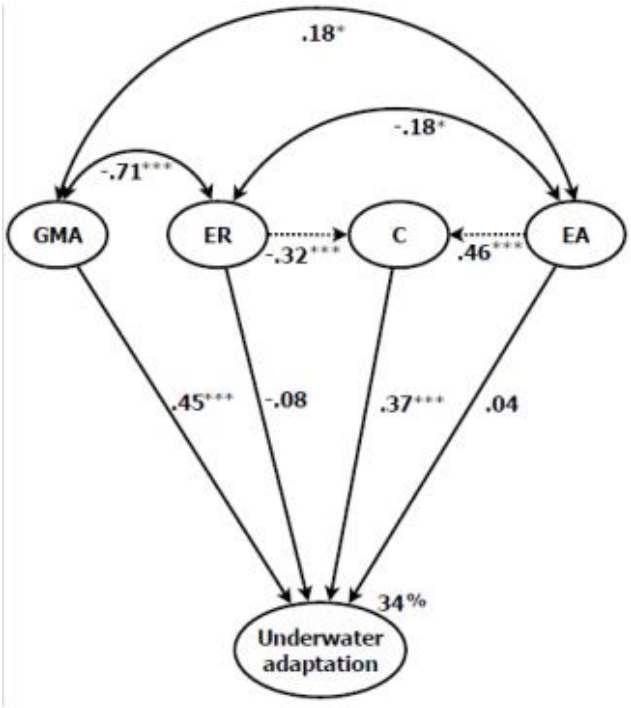

Figure 3. Structural model of underwater adaptation.
Direct (continuous line) and indirect (dashed line) effects. GMA = General mental ability; ER = Emotional reactivity; C = Conscientiousness; EA = Emotional adjustment.
$^{*}p<.05$, $^{***}p<.001$.

Altogether, the model presents a suitable fit, according to the values of the goodness of fit index (*GFI* = .98), the adjusted goodness of fit index (AGFI = .97), both above the limit of .90, and the root mean square error of approximation (RMSEA = .025), below the limit of .05 (Arbuckle, 2006; Hair et al., 2004; Hooper et al., 2008; Hu & Bentler, 1999). In addition, the final model significantly improves the fit to the empirical data, $\chi^2(1) = 21.91$, $p = .001$, adding two error covariances between tension with self-control and compliance, taking into account the negative relationship between the errors of the respective indicators and the modification indexes obtained in our hypothetical model. By comparing the estimated model with the independence model, which assumes that the covariances between the variables are zero, the values of the incremental fit indexes, normed fit index (*NFI* = .97), Tucker-Lewis index (*TLI* = .99) and comparative fit index (*CFI* = .99) exceed the required limit (.90) for our model to be accepted, as is corroborated by Hoelter's critical N (*N* = 544, $p = .05$).

In summary, the results of Table 4 are arguments in favor of the fit of the structural model of underwater adaptation, taking into consideration that the differences obtained between the empirical matrix and the variance-covariance matrix estimated from this model are due to random chance. The absolute, overall and comparative fit indexes support the conclusion of the model's suitability. The percentage of variance explained in the underwater adaptation was 34% in the final model, mainly based on the direct effects of general mental ability and conscientiousness and, additionally, on the indirect effects of emotional adjustment and emotional reactivity, as indicated by the standardized structural coefficients in Table 5.

Table 5. Structural relations between latent variables

		Efect			
	Correlation	Direct	Indirect	Total	Spurious
GMA → UA	.46	.45		.45	.01
C → UA	.38	.37		.37	.01
EA → C	.52	.46		.46	.06
ER → C	-.41	-.32		-.32	-.09
ER → UA	-.47		-.12	-.12	-.35
EA → UA	.27		.17	.17	.10

Note. GMA = General mental ability; UA = Underwater adaptation; C = Conscientiousness; EA = Emotional adjustment; ER = Emotional reactivity.

The relationships between the latent variables proposed in the final model were statistically significant at the level of $p < .001$, except those between emotional adjustment with general mental ability and emotional reactivity ($p < .05$). General mental ability ($\beta = .45$, *SE* = .11) had less explanatory significance in underwater adaptation than conscientiousness ($\beta = .37$, *SE* = .08). Similarly, emotional adjustment had greater relative weight ($\beta = .46$, *SE* = .06) than emotional reactivity ($\beta = -.32$, *SE* = .13) in conscientiousness. However, all of these regression coefficients were significant ($p < .001$).

Discussion

This study has analyzed the relevance of psychological variables in the adaptation to extreme environmental conditions, testing the structural relationships and the effects of observed and latent variables in adaptation to the underwater environment during basic military diving courses.

First of all, we tested the suitability of a measurement model of 4 latent variables obtained by CFA from 10 indicators of intelligence and personality, proposed on the basis of their predictive validity in diving. In previous studies we had

already observed, on the one hand, the direct linear relationship of general intelligence, reasoning, emotional stability, conformity, self-control and facilitating anxiety with underwater adaptation; and, on the other hand, the inverse relationship in the case of emotional sensitivity, insecurity, tension and inhibiting anxiety (Colodro, 2012; Colodro et al., 2014). General mental ability, conscientiousness and emotional adjustment had sufficient levels of composite reliability and validity, while emotional reactivity did not overcome the usually accepted thresholds (Hair et al., 2004).

Subsequently, we confirmed the causal model of underwater adaptation adjustment ($\chi^2(41) = 53.80$, $p = .087$) by SEM methodology, as shown by the thresholds of various fit indexes (Hooper et al., 2008; Hu & Bentler, 1999). The constructs of general mental ability and conscientiousness, in conjunction in the latter case with emotional adjustment and reactivity, have a significant explanatory effect in underwater adaptation, accounting for 34% of its variance. General mental ability ($\beta = .45$, $p < .001$) and conscientiousness ($\beta = .37$, $p < .001$) are directly and significantly related to underwater adaptation, which means that divers with higher scores in these variables adapt more efficiently to the underwater environment. Conscientiousness, in the case of diving, has the involvement of emotional adjustment ($\beta = .46$, $p < .001$) and the negative effect of emotional reactivity ($\beta = -.32$, $p < .001$), predicting that responsible, mature divers with low emotional reactivity achieve a more effective underwater adaptation. These data confirm the relationships of the latent variables proposed in our hypothetical model.

Taken together, our findings show that the current psychological models of intelligence, personality and performance are structurally related with the criterion of the operational adaptation of military divers. Intelligent people have more ability to understand diving situations and to acquire the technical knowledge and procedures that are necessary in the underwater environment. In addition, if they are characterized by being responsible, stable and low emotionally reactive, they will have a higher propensity to work hard and persistently, adapt to safety standards and deal more effectively with the complex situations that may occur in diving. In summary, these characteristics facilitate adaptive performance in a non-natural environment, enabling the divers to overcome the demands, incidents and critical circumstances of the underwater environment.

Indeed, these results agree with the predictions of human learning theories. On the one hand, they are similar to the studies where intelligence, the most general human mental ability, is conceived as a learning ability and problem-solving skill which promotes adaptation to new situations and environmental conditions (Gottfredson, 1997; Neisser et al., 1996); and, on the other hand, they are similar to the quantitative reviews where intelligence is considered to be the most important theoretical construct for personnel selection, especially in complex functions, and the best predictor of training in the civilian and military workplace (Hunter & Hunter, 1984; McHenry, Hough, Toquam, Hanson, & Ashworth, 1990; Ree & Earles, 1992; Ree, Earles, & Teachout, 1992; Salgado et al., 2003; Schmidt & Hunter, 1998, 2000, 2004).

These results are also consistent with the dominant theory of personality traits and studies that present personality factors as determinants of performance and behavior in the workplace (Barrick & Mount, 1991, 2003; Barrick et al., 2001; Hurtz & Donovan, 2000; Salgado, 1997, 1998, 2004; Tett et al., 1991). They also agree with the conclusions of meta-analytic reviews in which two personality factors, conscientiousness and emotional stability, have been accepted as significant predictors of training and performance in different positions and job activities and, in general, of adaptive performance. These two factors are often part of the theoretical foundation for the classification and selection of personnel (Barrick & Mount, 2000; Pulakos et al., 2002; Salgado, 1997).

Altogether, our results are also in line with traditional theories about the role of psychological variables in underwater adaptation. These theories were developed based on the first studies regarding the problems of the underwater environment and the psychological adaptation of divers (Adolfson, 1967; Bachrach et. al., 1976; Behnke, 1945; Bennett, 1966; Hoff & Greenbaum, 1948-1966; Shilling, Werts, & Schandelmeier, 1976), and their data have served as the basis for the safety and prevention measures in professional activities under water. They also coincide with previous studies carried out on samples of military divers, which evaluate the relationship of individual differences in intelligence and personality with criteria of training and adaptation in the underwater environment (Biersner & Larocco, 1987; Colodro, 2012; Colodro et al., 2014; Edmonds, 1972; Hogan & Hogan, 1985).

Therefore, this paper represents an advance in the knowledge of diving psychology, by proposing an explanatory underwater adaptation model that takes into account the predictive validity of intellectual characteristics and personality traits with regards to human adaptation in this field (Colodro et al., 2014). This model also takes into account the usefulness of anxiety measurement in predicting the difficulties of adaptation related to the onset of diving panic reaction and dysbaric accidents (Anegg et al., 2002; Morgan et al., 2004; Rieben & Miller, 2000; Tetlow, 2006). On the other hand, proposing a structural model contributes to understanding the relationship between the latent variables by determining the direct effect of general mental ability and conscientiousness on underwater adaptation and the direct intervention of emotional adjustment and the reverse relationship of emotional reactivity through conscientiousness. The model also corroborates in the diving field (1) the weak association between general mental ability and the two main factors of personality, conscientiousness and emotional stability (Ackerman & Heggestad, 1997), (2) the high empirical relationship between emotional stability and conscientiousness (Costa & McCrae, 1992), and (3) the significant association between general mental ability and emotional reactivity (De-

rakshan & Eysenck, 2009; Gutiérrez-Calvo & García-González, 2000).

From a practical viewpoint, we have found that intelligence and personality traits, grouped into 4 latent variables, provide the diver with the necessary potential to leverage the skills and personal resources in an non-natural environment, to apply self-control in unexpected and complex situations, to resolve stress factors under water and, ultimately, to meet the psychophysiological demands of the underwater environment, achieving an integrated and preventive level of adaptation in terms of safety.

General mental ability, the first latent variable in our model, is indicated by general intelligence (g^+) and reasoning (B^+), which assesses the understanding of relationships, problem solving, decision making, judgment of situations, abstract reasoning or knowledge acquisition and application of all of these factors in new contexts. These mental processes are the necessary foundation for understanding the specific environmental conditions of diving and the initial step in adapting to the stressful situations of underwater environment. General mental ability is, therefore, an operationally significant construct because it represents the capacity to manage the environmental circumstances of the underwater environment and to adapt to the changing and extreme situations encountered whilst under water (Ackerman & Kanfer, 1994; Bourne & Yaroush, 2003; Cohen, 1985).

The second latent variable, conscientiousness, is comprised of the indicators compliance (G^+) and self-control (Q_3^+). It represents the organization, perseverance, discipline and perfectionism that characterize self-control and concern for protocols. Control of one's own emotions and behaviors and success in containing anxiety are suitable characteristics for realizing the immersion and for accomplishing checks of the diving material and gear, favoring accuracy in underwater tasks and the application of the standards and procedures of scuba diving. Tenacity and discipline also contribute to underwater adaptation, especially in the presence of obstacles or in difficult situations (Barrick & Mount, 2000; Hurtz & Donovan, 2000; Martinez & Lemaire, 1992; Mount et al., 1999).

The third construct, emotional adjustment, is indicated by stability (C^+), insecurity (O^-), tension (Q_4^-), and inhibiting anxiety (IA^-). On the one hand, these variables are related with internal strength and the ability to control situations and emotions with adaptive equilibrium, promoting calm and stability in the presence of difficulties, and frustration tolerance. On the other hand, they have to do with the tendency to experience confidence in one's own resources and an adjusted concern regarding the risk involved. Furthermore, these variables reflect the levels of tension, excitability, and satisfaction with one's own possibilities. Finally, they take into consideration the presence of anxiety processes that may interfere with behavior through increased activation or excessive worry. Altogether, this latent variable is a basic requirement for keeping calm in a complicated underwater situation and for adaptation to an environment which is changing and prone to cause hazards. It is related to stress vulnerability and promotes functional and adaptive reactions in the underwater environment, preparing the diver to remain attentive to the environment and ready to implement the appropriate safety measures (Bar-Haim et al., 2007; Bolger, 1990; Carver & Connor-Smith, 2010; Conard & Matthews, 2008; Mogg et al., 2000; Staal, 2004; Vollrath, 2001).

Finally, emotional reactivity, defined by sensitivity (I^+) and facilitating anxiety (FA^-) indicators, expresses the prevalence of feelings over rational thinking in decision making and the predominance of emotional sensitivity over objectivity and practicality, together with the possibility of excessive activation and cognitive interference. The facility to be affected by the varied threatening or risk circumstances of the scuba diving activity, the inclination to respond to environmental stimuli through automatic or hypersensitive emotional responses and the tendency to produce irrelevant task responses are factors of a personal nature that may inhibit underwater adaptation and contribute to the occurrence of diving accidents or incidents. Emotional reactivity is a construct that has operational significance in the underwater environment, because the limited inclination to be affected by risk situations or stress vulnerability and the decisive help of the functional components of anxiety may be desirable in ensuring psychological adaptation, in order to regulate the behavioral reactions and avoid the perception of excessive environmental demands (Izard, 1993; Lazarus & Folman, 1984; Scherer, 2001; Vickers, Walton-Paxton, Hervig, & Conway, 1993).

Therefore, it is essential in professional diving to have a general mental ability that allows one to understand the environmental features of the underwater environment and to develop correct decision-making processes as a condition for producing the appropriate behavioral responses, prevent hazardous situations and maintain appropriate levels of activation. This is of paramount importance due to the well-known fact that the diver's intellectual ability is impaired under the water, which increases the likelihood of adaptive problems and the risk of accidents. By permitting the identification of dangerous stimuli, situational awareness and anticipation of risk circumstances, this construct can help to modulate emotional reactivity and overcome potentially stressful experiences, by avoiding the appraisal of excessive environmental demands with respect to the available personal resources. Similarly, given that the behavioral response in dangerous situations depends more on personal perception and interpretation than on the objective valence of the stressor, the emotionally mature diver can cope better with situations that are difficult for those who have a high level of anxiety, stress vulnerability or limited competence in their emotional reactivity. Emotional adjustment and reactivity, in turn, contribute to the possibility that the diver can control his behavior and apply the tenacity required to stay under water and carry out productive activities, respecting the safety regulations and executing the operational procedures of military diving.

Conclusions

In summary, the theoretical contribution of this work lies in clarifying the role of individual differences in the underwater environment by proposing a causal model of psychological adaptation in diving, whose components are constructs that may be the psychological basis for coping safely and performing productive activities in an extreme environment.

Furthermore, the results may have practical implications for the training of most qualified divers, they may guide clinical interventions to improve adaptation to the diving environment, and they may prove valuable in ethical and economic aspects related to the facet of risk prevention and safety in underwater activities.

This work, however, presents some theoretical and methodological limitations. The variables should be expanded in future research without restricting them to intelligence and personality indicators. In addition, some reasonable objectives are to employ new measuring instruments that share the psychological models used in this study and to analyze different samples of divers. The aims would be, on the one hand, to verify the importance of the latent variables referred to in our structural model to explain adaptation in the underwater environment; and, on the other hand, to generalize the results to the professional diving field, where similar requirements to achieve adaptation to the environment, analogous psychophysiological problems and identical diving techniques are found. Furthermore, we should consider the possibility of extending the assessment to areas other than dispositional traits, contemplating other psychological dimensions such as risk attitudes or core self-evaluations. Finally, we must improve the measurement model, especially in the latent variables with fewer indicators, and further develop the analysis of the direct and indirect effects of latent variables.

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