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Psychometric validation of the European Portuguese version of the Fatigue and Altered Cognition Scale (FACs)

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ABSTRACT

Background: Fatigue and “brain fog” are symptoms that may arise from lifestyle factors and various clinical conditions. Despite their significant impact on daily functioning, there is a lack of psychometrically robust instruments to measure their co-occurrence. The Fatigue and Altered Cognition Scale (FACs) was developed to address this gap, allowing the assessment of central fatigue and cognitive complaints commonly referred to as brain fog. In the present study, we translated, culturally adapted, and validated the FACs for European Portuguese.

Methods: A sample of 591 Portuguese-speaking adults completed the Portuguese version of the FACs, along with the Burnout Assessment Tool (BAT) and the Depression, Anxiety, and Stress Scales (DASS). Confirmatory Factor Analysis tested the factorial structure, and internal consistency and convergent validity were also evaluated.

Results: A bifactor model demonstrated the presence of a general factor underlying all items. Internal consistency was excellent, and the FACs exhibited strong positive correlations with both the BAT and the DASS. Moreover, the FACs demonstrated strong criterion-related validity through its significant and robust associations with burnout, depression, anxiety, and stress.

Conclusions: Our findings establish the FACs as a valid, reliable, and efficient instrument for both clinical and research applications within European Portuguese contexts.

KEYWORDS

Altered cognition; brain fog; FACs; fatigue; fatigue and Altered cognition scale

Introduction

Fatigue and brain fog are closely linked symptoms that can significantly impair daily functioning. These symptoms may arise from lifestyle-related factors such as insufficient sleep or an unbalanced diet, but they are also associated with a wide range of clinical conditions that include chronic pain (Dass et al., 2023) traumatic brain injury (Ponsford et al., 2011), chronic fatigue syndrome (Ocon, 2013), hypoparathyroidism (Coles et al., 2019), celiac disease (Yelland, 2017), postural tachycardia syndrome (Wells et al., 2020), cancer treatments (Pan & Hu, 2024), fibromyalgia (Kravitz & Katz, 2015), rheumatoid arthritis (Katz et al., 2004), and post-acute sequelae of COVID-19 (Thaweethai et al., 2023).

Fatigue and brain fog are terms that have been frequently used without clear definitions, hindering the understanding, assessment, and treatment of these symptoms (Elliott et al., 2023). Fatigue is a complex symptom reported by both healthy individuals and those with acute or chronic conditions. It often co-occurs with depression, pain, sleep

impairment, and cognitive dysfunction (Kinsinger et al., 2010), leading to a wide range of negative effects, from reduced productivity and occupational hazards to professional errors or even suicidal ideation (Fan & Smith, 2017; Kapur & Webb, 2016).

Given its widespread impact across populations, a recent review aimed to clarify how fatigue is defined and measured in non-oncologic medical conditions (Billones et al., 2021). The authors included 47 articles that identified eight fatigue dimensions: physical, cognitive, mental, central, peripheral, emotional, motivational, and psychosocial (Billones et al., 2021). Physical fatigue was the most frequently assessed dimension, described as a “debilitating physical exhaustion or a distressing lack of energy not relieved by sleep or rest” (Norton et al., 2015), or as “muscle fatigability,” defined as difficulty initiating or sustaining muscular activity (Elsais et al., 2013; see Billones et al., 2021 for the definitions of other dimensions of fatigue). The FACs was specifically developed to assess central fatigue, (Elliott et al., 2023),

which is linked to dysfunctions within the central nervous system, leading to an increased perception of effort and reduced endurance for sustained physical and mental tasks (Chaudhuri & Behan, 2004). Individuals experiencing central fatigue often report difficulties initiating, sustaining activities, or maintaining focus (Chaudhuri & Behan, 2004).

Brain fog is a term commonly used to describe subjective difficulties with thinking and concentration, including forgetfulness, lack of mental clarity, slower conversational responses, and word retrieval problems (Bell et al., 2023; Ross et al., 2013). It encompasses episodes of mental cloudiness, impaired attention, concentration, speech, organization, multitasking, and memory (Atik & İnel Manav, 2023; Lucius, 2021). These cognitive difficulties can lead to reduced work efficiency, feelings of disappointment and inadequacy, academic and occupational challenges, accidents, strained relationships, loneliness, low self-esteem, and other psychosocial impacts (Kovalchuk & Kolb, 2017; Lucius, 2021; Ocon, 2013; Yelland, 2017).

The frequent co-occurrence of central fatigue and brain fog across general population and chronic health conditions has prompted investigation into potential shared mechanisms (Elliott et al., 2023). Although their etiology is likely multifactorial, a thorough assessment of symptom presence and severity remains a crucial step before designing effective interventions. However, until recently, the absence of a specific instrument led researchers to rely on multiple overlapping neuropsychological tests to assess central fatigue and brain fog (Krishnan et al., 2022; Ocon, 2013; Wright et al., 2020). Nevertheless, using several neuropsychological measures is burdensome, time-consuming and costly, introducing risk biases, such as increased patient fatigue or reduced statistical power in research (Billones et al., 2021; Elliott et al., 2023). Moreover, many traditional cognitive tests, developed for severe neuropsychological impairments, lack sensitivity to the subtle fluctuations that are characteristic of brain fog (Wright et al., 2020).

To address these challenges, the Fatigue and Altered Cognition Scale (the FACs) was designed to provide a sensitive, efficient, and psychometrically robust self-report measure of central fatigue and brain fog across diverse populations or conditions (Elliott et al., 2023). It was developed by researchers and clinicians with expertise in treating traumatic brain injury-related symptoms. Item generation was informed by existing literature and reviews of patient responses from previous and ongoing traumatic brain injury studies. This process resulted in 20 items—ten assessing altered cognition (i.e., brain fog) and ten assessing central fatigue. In the original study, Cronbach's alpha coefficients indicated excellent internal consistency for both factors ($\alpha = .95$), and Omega values were similarly strong ($\omega = .95$). A confirmatory factor analysis supported the proposed two-factor model (Elliott et al., 2023).

Although various instruments assess fatigue (Billones et al., 2021) or brain fog (Atik & İnel Manav, 2023) separately, the FACs captures their co-occurrence, focusing on symptoms potentially linked by common pathophysiological mechanisms (Elliott et al., 2023). For this reason, our study reports the adaptation of the FACs into European Portuguese

and evaluates its psychometric properties. Moreover, we tested the validity of the FACs to distinguish between participants with low and high levels of burnout, depression, anxiety, and stress. This process is essential to provide clinicians and researchers from European Portuguese contexts with a reliable, culturally adapted tool that facilitates accurate symptom assessment, supports clinical decision-making, monitors treatment response, and enhances cross-cultural research. The relevance of this work is amplified by the expanding recognition of central fatigue and brain fog in a wide range of clinical conditions.

Methods

Participants

In this cross-sectional study, a non-probabilistic convenience sample was collected through a snowball method. Participants were reached by posts on social media platforms (e.g., Facebook and LinkedIn) and by contacts of university students who agreed to disseminate the study within their personal networks. Inclusion criteria required participants to be over 18 years of age and to have European Portuguese as their dominant language.

Instruments

Besides a *socio-demographic questionnaire*, which included questions about age, gender, academic degree, and marital status, the Portuguese versions of the following instruments were administered.

Burnout Assessment Tool (BAT; Schaufeli, Desart, et al., 2020)

The BAT is a self-report instrument that conceptualizes burnout as a syndrome consisting of four core symptoms—exhaustion, mental distance, emotional impairment, and cognitive impairment (which are assessed through 23 items), and secondary symptoms—psychological distress and psychosomatic complaints (measured by an additional 10 items). These secondary symptoms may be associated with depressed mood and other comorbidities. All items are rated on a five-point Likert scale ranging from 1 (“Never”) to 5 (“Always”). In the framework of this instrument, the four core symptoms are interconnected and reflect a common higher-order factor—burnout—which is treated as a second-order construct (Schaufeli, Desart, et al., 2020; Sinval et al., 2022). Exhaustion is assessed through eight items, while each of the remaining core and secondary dimensions is measured with five items.

In the present study, we used BAT-23, to assess the core symptoms of burnout. Thereby, we assessed: (a) *exhaustion*, which refers to a severe loss of energy that results in feelings of both physical (tiredness, feeling weak) and mental (feeling drained and worn-out) exhaustion—Specific symptoms of exhaustion include lack of energy to start a new job, feeling completely used up after a whole day of work, feeling tired quickly even after spending minimal effort at work, and inability to relax after work; (b) *emotional impairment*, which

refers to the manifestation of intense emotional reactions and feelings of being overwhelmed by one's emotions—Specific symptoms of emotional impairment include feeling frustrated and angry at work, irritability, overreacting, feeling upset or sad without knowing why, and feeling unable to control one's emotions at work; (c) *cognitive impairment*, which refers to memory, attention and concentration deficits, as well as poor cognitive performance—Specific symptoms of cognitive impairment include difficulties of thinking clearly and learning new things at work, being forgetful and absent-minded, indecision, poor memory, attention and concentration at work. Finally, we assessed (d) *mental distance*, which refers to a psychological detachment from work, often accompanied by a strong reluctance or aversion to engaging in work-related activities—common symptoms of mental distance include mental or physical withdrawal from work, avoidance of interactions with others (such as customers, clients, or colleagues), indifference, a cynical attitude, and a lack of enthusiasm or interest in tasks, which are often performed on autopilot (Schaufeli, De Witte, et al., 2020). In this study, the total score (ranging from 23 to 115) was calculated by summing the scores of all 23 core items, with higher scores indicating higher levels of burnout.

The Fatigue and Altered Cognition Scale (FACs; Elliott et al., 2023)

The FACs is a 20-item self-report measure in which participants rate the frequency and severity of experiencing fatigue and brain fog (labeled as “altered cognition”) over the two previous weeks. The Altered Cognition Scale contains 10 items and the Fatigue Scale contains another 10 to assess central fatigue. In the original version of the FACs, participants provided their responses through a visual analog scale (VAS). In this response format, each item was anchored with descriptors indicative of extreme responses (“not at all” to “extremely”), and responses to each item were provided using a “drag and drop” slider bar. Participants moved the slider along a horizontal line to denote their response, allowing them to give a 0 to 100 score for each item. However, in the Portuguese version of the FACs, we replaced the VAS with a ten-point Likert-type scale using the same anchors – 1 (“Not at all”) to 10 (“Extremely”). This modification was made to enhance ease of use (including on paper-based settings), reduce cognitive load, and ensure greater clarity and consistency in responses, particularly among participants with lower digital literacy. Hence, the total score of the Portuguese version of the FACs ranges from 20 to 200, calculated by summing the scores of all items, with higher scores indicating greater symptom severity (Elliott et al., 2023).

Depression Anxiety Stress Scales (DASS; Lovibond & Lovibond, 1995)

The DASS is a 21-item self-report measure in which participants rate the frequency and severity of experiencing negative emotions over the previous week (Lovibond & Lovibond, 1995; Pais-Ribeiro et al., 2004). Each item is rated on a four-point Likert scale ranging from 0 (“Did not apply to me at all”) to 3 (“Applied to me very much or most of the time”). The measure is divided into three subscales: Depression, Anxiety, and Stress, each comprising seven items. Depression symptoms include dysphoria, hopelessness, devaluation of life, self-deprecation, lack of interest or involvement, anhedonia, and inertia. Anxiety symptoms involve autonomic arousal, musculoskeletal tension, situational anxiety, and subjective feelings of fear and worry. Stress symptoms include difficulty relaxing, nervous arousal, being easily upset or agitated, irritability or overreactivity, and impatience. The scale provides for scores, one per subscale (with a minimum of 0 and a maximum of 21) and one total score (with a minimum of 0 and a maximum of 63). The scores on each scale are determined by adding scores on the seven items, while the total score is determined by adding scores on the 21 items. Higher scores correspond to more negative affective states (Lovibond & Lovibond, 1995; Pais-Ribeiro et al., 2004).

Procedures

Translation and cultural adaptation of the FACs for the Portuguese population

The translation of the FACs followed the guidelines of the International Test Commission (International Test Commission, 2017), which are shown in Figure 1. The first step was to get permission to use the scale for scientific purposes by their principal author (Elliott et al., 2023). Second, two independent psychologists performed the translation (CF and CB), and conflicts were resolved with the help of a third one (FB). After, a bilingual expert in Psychology, who was external to the team, performed the back-translation, which was approved by the authors of the original version of the instrument (see the results of translation and back-translation on Table 1). After obtaining the final version of the Portuguese translation, a pilot study was conducted with a sample of 10 participants for a semantic analysis. All participants responded that the version was fully understandable and, as a results no modifications were made. In the Portuguese version, the FACs is titled “*Questionário de Fadiga e Cognição Alterada*” and is available in the [supplementary material](#).

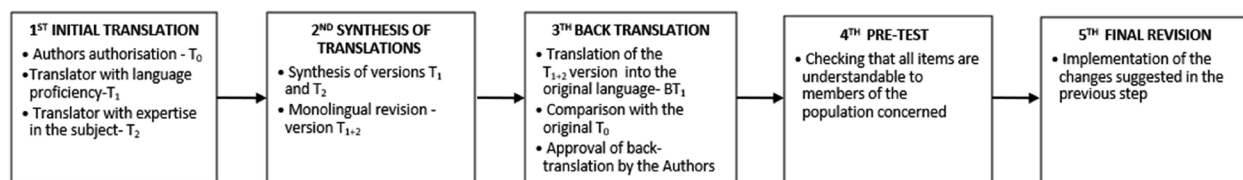


Figure 1. Translation process stages.

Table 1. Translation and back-translation of the FACs.

Item #	Original version	Portuguese Translation	Back-translation
1	I felt fatigued	Senti-me fatigado/a	I felt fatigued
2*	I felt alert	Senti-me alerta	I felt alert
3	I lost track of what I was going to say	Perdi a noção do que ia dizer	I lost track of what I was going to say
4	I was forgetful	Estive esquecido/a	I was forgetful
5	I had trouble concentrating	Tive dificuldades em concentrar-me	I had trouble concentrating
6	I felt worn out	Senti-me exausto/a	I felt exhausted
7	I felt sluggish	Senti-me lentificado/a	I felt slowed down
8	I felt run down	Senti-me esgotado/a	I felt burned out
9	I had trouble focusing on things I wanted to do	Tive dificuldade em focar-me nas coisas que queria fazer	I had difficulty focusing on the things I wanted to do
10*	I had the energy to do what I wanted to do	Tive energia para fazer o que queria fazer	I had the energy to do what I wanted to do
11	I was easily confused	Fiquei facilmente confuso/a	I was easily confused
12	I felt "spaced out" like I was in a fog	Senti-me "desorientado/a," como se estivesse no mundo da lua	I felt "disoriented," as if I was in a daze
13	I had to force myself to get things done	Tive de me forçar a fazer as coisas	I had to force myself to do things
14*	I was clearheaded	Estive lúcido/a	I was lucid
15	I felt tired	Senti-me cansado/a	I was tired
16	I didn't process things as quickly or accurately as I should have	Não processei as coisas tão rapidamente ou acertadamente como deveria	I did not process things as fast and accurately as I wanted
17	I had to struggle to finish what I started to do	Tive de me esforçar para terminar o que comecei a fazer	I had to make an effort to finish things I started to do
18	I had trouble paying attention	Tive dificuldade em prestar atenção	I had difficulty paying attention
19	It was hard for me to make up my mind and reach a decision	Foi difícil para mim chegar a uma conclusão e tomar uma decisão	It was difficult for me to reach a conclusion and make a decision
20	I had problems feeling energetic no matter if I slept or napped	Tive problemas em sentir-me com energia, independentemente de dormir ou descansar	I had trouble feeling energized regardless of sleeping or resting

*Inverted items.

Data collection

This study is a descriptive, observational, cross-sectional quantitative study based on a convenience sample. Formal authorization was provided by the authors of the original instruments, and the study was approved by the local ethics committee (reference FCHS/PI475/23). Participants gave their informed consent to participate, after the confidentiality and anonymity of the data were ensured. Regarding the sample size calculation, it is suggested an item-response ratio ranging from 1: 5 to 1:10. To ensure more robust results, we opted for the more conservative method and considered a 1:10 ratio, which required a minimum sample size of 200 participants since the FACs is composed of 20 items (Osborne & Costello, 2004).

Data analysis

Analyses were conducted using the Statistical Package for the Social Sciences (SPSS) 30, except for Confirmatory Factor Analysis (CFA), which was performed using R (Version 4.4.1). All statistical tests were conducted at a significance threshold of $\alpha = .05$. Descriptive statistics were calculated for continuous variables, including mean (M), standard deviation (SD), and range (minimum and maximum values). For categorical variables, absolute (n) and relative (%) frequencies were computed. Item response distributions, along with the main descriptive statistics, were also examined for the 20 items (mean, standard deviation, range, and skewness).

Construct validity, defined as how well the instrument captures a concept that is not directly measurable, was assessed by performing a Confirmatory Factor Analysis (CFA). CFA tests whether the data fit the hypothesized

model, examining the factor structure of the instrument. Common fit indices used include: the Comparative Fit Index (CFI; values above .90 indicate a good model fit); the Tucker-Lewis Index (TLI; values above .90 suggest a good fit); the Root Mean Square Error of Approximation (RMSEA; values below 0.08 indicate acceptable fit), and the Standardized Root Mean Square Residual (SRMR; values below .08 indicate a good model fit; Hu & Bentler, 1999).

The internal consistency of the instrument was evaluated using Cronbach's alpha (α), which assesses how well a set of items measures an underlying construct. Values range from 0 to 1, with higher values indicating greater consistency. Typically, $\alpha < .70$ suggests inadequate reliability, $.70 \leq \alpha < .80$ indicates acceptable internal consistency, $.80 \leq \alpha < .90$ indicates good internal consistency, and $\alpha \geq .90$ indicates excellent internal consistency. However, excessively high values (e.g., $\alpha > .95$) may point to redundancy, where items are too similar and may not contribute unique information (Streiner, 2003; Tang et al., 2014).

Convergent validity—defined as the extent to which scores from one instrument correlate with those from another validated instrument measuring the same or a similar construct—was evaluated using Pearson's correlation coefficient. Correlations were computed between the total scores of the FACs and the BAT, as well as between the FACs and the DASS. A strong and statistically significant correlation (typically $r > 0.50$) is indicative of good convergent validity (Streiner et al., 2024).

To examine the predictive value of the FACs on mental health outcomes, linear regression analyses were conducted. The total scores from the FACs were entered as the independent variable into separate regression models that were run for each outcome variable—the BAT and the DASS-21.

Results

The sample consisted of 591 adult participants (373 Female; $M_{age} = 43.2$; $SD_{age} = 12.6$; Age range = 18–74), exceeding the minimum threshold for statistical power ($n=200$). Most participants were married (57.9%) and highly educated: 45.0% held a bachelor's degree, 14.0% a master's, and 3.9% a doctorate. An additional 24.2% completed secondary education, while lower levels of schooling were less common (12%). Participants worked across diverse sectors, with Education (33.8%), Industry and Construction (20.8%), and Commerce and Services (17.9%) being the most represented. Most held permanent contracts (80.0%), while 12.9% had fixed-term and 6.1% temporary, freelance or self-employed, and 1.0% of the sample were unemployed. Regarding the results of the FACs, Table 2 displays the descriptive statistics of the 20 items, while Table 3 displays the normative data for FACs total score by age group.

All items had minimum scores of 1 and maximum scores of 10, indicating that participants used the full range of the scale to report their levels of fatigue and altered cognition. Skewness values ranged from -0.07 to 1.06 , suggesting generally symmetric response distributions, while kurtosis values ranged from -1.34 to 0.14 , reflecting relatively flat distributions. These findings support the conclusion that the response patterns for the 20 FACs items were approximately normally distributed (Hair et al., 2022). The item means for the FACs ranged from 3.27 (item 12) to 5.68 (item 15), suggesting a broad distribution of symptom intensity across items. Standard deviations ranged from 2.50 to 3.06 points, and assuming approximately normal distributions, this

suggests that around 68% of participant responses fell within one standard deviation ($\pm 1 SD$) of the mean, approximately between 3.50 and 6.50 points. This indicates that the FACs items were capable of capturing a wide spectrum of symptom intensities in the sample.

Construct validity

To determine whether Elliott and colleagues' (2023) two-factor structure could be replicated in the Portuguese sample, a CFA was computed. The model showed a statistically significant chi-square, $\chi^2(169) = 1996.48$, $p < .001$. In addition, the other fit indices suggested suboptimal fit: the CFI was .856 and the TLI was .838, both below the commonly accepted threshold of .90. The RMSEA was 0.135, $p \leq .05$ (90% CI [0.130, 0.141]), which exceeds the acceptable limit of .08. Only the SRMR met acceptable criteria, with a value of .079, suggesting acceptable residual levels (Hu & Bentler, 1999). Overall, these results indicate that the original two-factor model did not adequately fit the Portuguese data, which may be explained by the high correlation between the two latent factors ($r = .85$). This correlation suggests that these factors might reflect a shared underlying construct. In such cases, a bifactor model, in which the two first-order factors (e.g., "Fatigue" and "Altered Cognition") load onto a second-order general factor may be more appropriate. This structure maintains the identity of each domain while acknowledging that they may stem from a broader latent dimension.

To test whether a bifactor model would better represent the structure of the scale in the Portuguese sample, a new CFA was conducted. The model showed a statistically significant chi-square, $\chi^2(150) = 973.08$, $p < .001$, but the CFI was .935 and the TLI was .918, both surpassing the commonly accepted threshold of 0.90. The RMSEA was 0.096 (90% CI [0.091, 0.102]), which is slightly above the ideal cutoff of .08, while the SRMR was .050, within acceptable limits ($< .08$; Hu & Bentler, 1999). Overall, these results support the bifactor structure as a better-fitting model. Notably, the general factor exhibited strong standardized loadings across all items and excellent reliability ($\omega = .97$), while the specific factors showed weak unique contributions ($\omega^2 = .13$ for Fator1 and .07 for Fator2), suggesting that the instrument functions primarily as a unidimensional measure. This structure captures the shared variance across all items, while the specific dimensions ("Fatigue" and "Altered Cognition") appear to contribute little unique information once the general factor is accounted for (Figure 2).

Internal consistency

The internal consistency of the FACs was excellent, with a Cronbach's alpha of $\alpha = .95$. The other instruments used in the study also showed excellent reliability, with Cronbach's alpha of $\alpha = .96$ for both the BAT and the DASS.

Convergent validity

Convergent validity was assessed by calculating the Pearson's correlation coefficient between the FACs and the BAT, as well as between the FACs and the DASS. The correlation

Table 2. Descriptive statistics of the 20 FACs items.

Item #	Min	Max	Mean	SD	Skewness	Kurtosis
1	1	10	5.60	2.72	0.04	-1.14
2*	1	10	5.09	2.61	0.22	-0.86
3	1	10	3.95	2.73	0.64	-0.76
4	1	10	3.93	2.66	0.68	-0.62
5	1	10	4.08	2.66	0.62	-0.69
6	1	10	5.53	2.96	0.02	-1.34
7	1	10	4.23	2.74	0.48	-0.95
8	1	10	5.07	3.06	0.17	-1.33
9	1	10	4.26	2.82	0.52	-0.91
10*	1	10	5.12	2.58	0.16	-0.92
11	1	10	3.47	2.50	0.89	-0.14
12	1	10	3.27	2.54	1.06	0.14
13	1	10	4.20	2.87	0.53	-0.96
14*	1	10	3.74	2.83	0.88	-0.34
15	1	10	5.68	2.93	-0.07	-1.25
16	1	10	4.40	2.70	0.44	-0.91
17	1	10	4.52	2.90	0.38	-1.08
18	1	10	4.02	2.69	0.62	-0.71
19	1	10	3.93	2.67	0.62	-0.72
20	1	10	4.69	3.00	0.35	-1.18

Notes. Min: minimum value observed; Max: maximum value observed; SD: standard deviation. *Reverse coded before conducting item analyses.

Table 3. Normative data for FACs total score by age group.

Age Group	N	Mean	SD	Median	Min	Max	95% CI (Lower)	95% CI (Upper)
18–30	132	92.73	38.06	88.0	27	194	86.17	99.28
31–45	155	86.55	41.71	80.0	20	190	79.94	93.17
46–60	261	87.94	40.59	87.0	20	194	83.0	92.89
61+	40	89.85	44.37	87.5	24	200	75.66	104.04

Notes. Min: minimum value observed; Max: maximum value observed; SD: standard deviation.

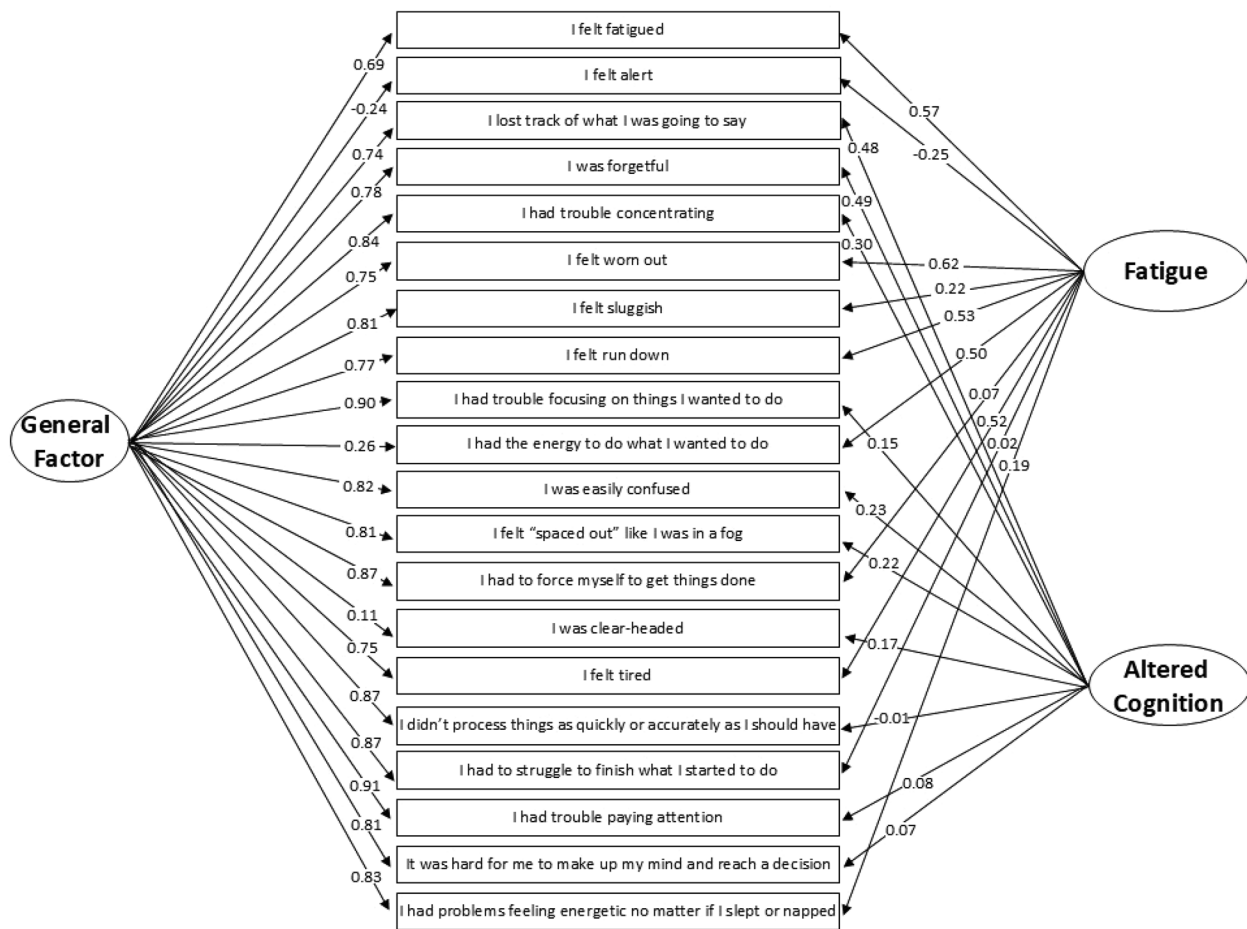


Figure 2. Bifactor model of the FACs.

Note. All items load on a General Factor, representing a shared underlying dimension, while subsets of items also load on specific factors: Fatigue and Altered Cognition. Numbers on arrows represent standardized factor loadings. The specific factors are orthogonal to the General Factor and to each other. This model has an acceptable fit, $\chi^2(150) = 973.08$, $p < .001$, CFI = .935, TLI = .918, RMSEA = 0.096, SRMR = .05.

between the FACs and the BAT was very strong ($r = .799$, $p < .001$), as well as the correlation between the FACs and the DASS ($r = .721$, $p < .001$). These findings support the convergent validity of the FACs, demonstrating that it correlates significantly with other established measures assessing similar constructs (Streiner et al., 2024).

Predictive role of the FACs

A simple linear regression was conducted to examine whether scores on the FACs predicted burnout symptoms, as measured by the BAT. The model was statistically significant, $F(1, 589) = 1039.21$, $p < .001$, and accounted for a substantial portion of the variance in burnout scores, $R^2 = .638$. FACs scores were a significant positive predictor of BAT scores, $B = 0.36$, 95% CI [0.34, 0.38], $\beta = .80$, $t(589) = 32.24$, $p < .001$. This suggests that greater severity of central fatigue and altered cognition symptoms is strongly associated with higher levels of burnout.

This statistical model was then repeated to assess whether FACs scores could also predict anxiety, depression, and stress symptoms, as measured by the DASS subscales. For anxiety, the regression model was statistically significant, $F(1, 589) = 402.52$, $p < .001$, explaining 40.6% of the variance ($R^2 = .406$). FACs scores significantly predicted anxiety, $B = 0.072$, 95% CI [0.065, 0.079], $\beta = .64$, $t(589) = 20.06$, $p < .001$,

indicating that greater symptom severity is associated with higher anxiety levels.

For depression, the model was also significant, $F(1, 589) = 516.27$, $p < .001$, and explained 46.7% of the variance ($R^2 = .467$). FACs scores significantly predicted depressive symptoms, $B = 0.082$, 95% CI [0.075, 0.090], $\beta = .68$, $t(589) = 22.72$, $p < .001$, suggesting that higher levels of fatigue and cognitive impairment symptoms are strongly associated with increased depression.

Finally, for stress, the model was significant as well, $F(1, 589) = 588.02$, $p < .001$, accounting for 50.0% of the variance in stress scores ($R^2 = .500$). FACs scores were a significant predictor of stress, $B = 0.091$, 95% CI [0.083, 0.098], $\beta = .71$, $t(589) = 24.25$, $p < .001$. These results indicate that higher symptom severity is strongly associated with elevated stress levels.

Discussion

The Fatigue and Altered Cognition Scale (FACs; Elliott et al., 2023) is designed to assess the co-occurrence of central fatigue and cognitive complaints commonly referred to as "brain fog." To make this instrument accessible to European Portuguese-speaking populations, this study aimed to translate and culturally adapt the FACs into European

Portuguese and evaluate its psychometric properties. Additionally, we examined the scale's discriminative capacity in distinguishing between individuals with varying levels of burnout, depression, anxiety, and stress. To this purpose, data were collected from a sample of 591 participants, which responded to the translated version of the FACs, along with the Burnout Assessment Tool (BAT; Sinval et al., 2022) and the Depression, Anxiety, and Stress Scales (DASS-21; Pais-Ribeiro et al., 2004).

The translated version of the FACs presented an excellent internal consistency, in line with the results of the original version (both $\alpha = .95$; Elliott et al., 2023). This equivalent internal consistency is noteworthy given a key methodological difference between the two versions in the response format. In the original study (Elliott et al., 2023), responses were recorded using a visual analogue scale ranging from 0 ("Not at all") to 100 ("Extremely"), administered via a digital platform. This format allows fine-grained distinctions in self-reported symptom severity and is well-suited for tech-enabled environments, particularly in clinical settings with digital infrastructure. However, the Portuguese version adopted a 10-point Likert-type scale, ranging from 1 ("Not at all") to 10 ("Extremely"). This adjustment was made to improve accessibility, especially for participants with lower digital literacy (highly frequent in Portuguese samples), and to facilitate paper-based administration.

Although a direct psychometric comparison between the original VAS and the 10-point Likert scale was not feasible in this study, we explored potential loss of variance and sensitivity. Descriptive item analyses indicated that all response categories (1–10) were utilized across all items, with approximately normal distributions, low skewness, and no evidence of ceiling or floor effects (see Table 2). Nonetheless, we recognize that the Likert format may limit sensitivity to subtle variations in symptom severity compared to a continuous VAS. Future studies may address this limitation by administering both formats to the same sample.

Despite this modification, the internal consistency of the Portuguese version remained high, suggesting that the FACs' item structure is inherently strong and stable across formats. The high alpha indicates that the scale items cohere well, regardless of whether respondents use a continuous (VAS) or ordinal (Likert) scale. This finding supports the flexibility and adaptability of the FACs in diverse contexts. It also underscores that changing the response format, when done with proportionally equivalent anchors, does not compromise the psychometric quality of the instrument, while it may enhance the tool's utility in low-resource settings or populations less familiar with digital technologies.

Regarding the construct validity, while the original version of the FACs proposed a two-dimensional structure (fatigue and altered cognition), the results of the present study indicated that this structure, although theoretically valid, did not demonstrate an ideal statistical fit in the Portuguese sample. Specifically, the CFI and TLI indices fell short of conventional reference values, and the RMSEA was higher than the recommended value, suggesting a model with suboptimal fit. However, the high correlation between the first-order factors indicated a substantial overlap between

the fatigue and altered cognition constructs, supporting the exploration of a bifactor model. This model demonstrated a better fit to the data, revealing the existence of a dominant general factor. This pattern is indicative that, although the domains "fatigue" and "altered cognition" are theoretically distinct, in empirical practice the symptoms that comprise them seem to reflect a broader unidimensional construct, potentially, a global state of psychocognitive exhaustion.

The presence of a dominant general factor in the bifactor model has important implications for clinical application. Given the strong loadings on the general factor and the limited unique variance explained by the specific factors, we recommend that the FACs be primarily used as a unidimensional measure, with the total score serving as the most reliable and psychometrically robust index of psychocognitive burden. Nonetheless, subscale scores for Fatigue and Altered Cognition may still offer descriptive or exploratory value in specific clinical contexts (for example, when a practitioner is interested in identifying whether fatigue or cognitive complaints are more pronounced in a particular individual). While these scores should be interpreted with caution, they may still provide useful qualitative information to inform clinical judgment.

This finding is consistent with the literature that points to the difficulty in dissociating central fatigue from altered cognition in clinical and occupational contexts (Elliott et al., 2023; Krishnan et al., 2022). In such cases, when the two proposed factors are extremely highly correlated, a more parsimonious single-factor solution or bifactor model often provides a better fit. For instance, as pointed by Brown (2015), factor intercorrelations above .80–.85 suggest that the factors may not be truly distinct and that a simpler unidimensional structure could be more appropriate (Brown, 2015).

Consistent with this assumption, studies have found that originally separate fatigue subdomains collapse into one dominant factor (Chilcot et al., 2016). When validating the Chalder Fatigue Questionnaire in multiple sclerosis (Chalder et al., 1993), the authors reported that a bifactor model with one general fatigue factor (and two small group factors for mental and physical fatigue) fits best, indicating a common overarching fatigue construct (Chilcot et al., 2016). Similarly, other study showed that concussion symptoms were best explained by a bifactor structure with a large general factor (encompassing cognitive and fatigue symptoms) and smaller specific factors. This structure demonstrated predominant unidimensionality, despite the diverse symptom domains (Brett et al., 2020). These findings reinforce that although fatigue and cognitive complaints can be conceptually distinct, empirically they often share so much variance that a single general factor accounts for most of the covariance.

The close link between central fatigue and cognitive difficulties (often described as *brain fog* or mental fatigue) has been documented across various conditions. In chronic fatigue syndrome, for instance, patients describe brain fog as a state of slowed thinking, confusion, and forgetfulness, essentially the subjective experience of mental fatigue coupled with mild cognitive impairment. In this context, brain fog can be conceptualized as the perception of mental fatigue associated with cognitive inefficiency, highlighting that these symptoms are

deeply tangled (Ocon, 2013). Likewise, fatigue and cognitive complaints frequently co-occur and show substantial overlap in neurological conditions like multiple sclerosis (Ocon, 2013) or traumatic brain injury (Elliott et al., 2023).

Researchers have found that attempting to separate physical fatigue from cognitive fatigue often proves difficult: a general fatigue factor tends to dominate, with mental and physical aspects loading onto that single broad factor (Plow & Gunzler, 2022). Other study also demonstrated that what might appear as “energy” versus “fatigue” dimensions actually reflects one underlying continuum of vitality. In their comprehensive item bank analysis, a bifactor model yielded one major vitality factor accounting for ~69% of variance, with only minor residual group factors for energy and fatigue (Deng et al., 2015).

Taken together, these studies suggest a common pathway or unified construct underlying fatigue and cognitive symptoms. Even if we label them as separate domains (e.g. “fatigue” vs. “altered cognition”), in practice, they often present as a single global state of psychocognitive exhaustion, characterized by the co-occurrence of pronounced fatigue and cognitive clouding. This supports the use of a bifactor or unidimensional model for instruments like the FACs, capturing the overarching factor that these symptoms share while still acknowledging their specific facets. Thus, the Portuguese version of the FACs, despite maintaining the two domains, appears to operate primarily as a unidimensional measure of altered psychocognitive severity. Accordingly, scoring the FACs using a total score, rather than computing separate scores for each subscale, may be more appropriate for both clinical interpretation and research applications.

The results of the convergent validity analysis revealed strong correlations with other Portuguese validated instruments, specifically the BAT (Sinval et al., 2022) and the DASS (Pais-Ribeiro et al., 2004). These results corroborate the convergent validity of the FACs, reinforcing its usefulness as a valid psychometric tool to assess symptoms of exhaustion and altered cognition in different contexts.

The BAT was used to assess the convergent validity of the FACs because it conceptualizes burnout as a syndrome marked by extreme exhaustion and cognitive impairment—core features that overlap with central fatigue and “brain fog” as measured by the FACs (Schaufeli, Desart, et al., 2020; Schaufeli, De Witte, et al., 2020). Exhaustion in burnout reflects a state of chronic fatigue, while cognitive impairment involves difficulties with concentration, memory, and mental clarity (Schaufeli et al., 2020). This theoretical alignment suggests that individuals with high FACs scores are also likely to report elevated burnout symptoms, particularly on the exhaustion and cognitive impairment subscales. Thereby, the BAT offers a multidimensional profile of burnout that conceptually mirrors the constructs assessed by the FACs.

Similarly, the DASS was also used to assess the convergent validity of the FACs due to its measurement of psychological distress across three domains: depression, anxiety, and stress. These constructs conceptually intersect with central fatigue and cognitive complaints. Fatigue and concentration difficulties are common symptoms of both mood and

anxiety disorders, as reflected in the DSM-5 criteria for Major Depressive Disorder and Generalized Anxiety Disorder (Hsiao et al., 2024). The DASS Stress subscale, which captures chronic tension and difficulty relaxing, is particularly relevant given its association with mental fatigue. High perceived stress has been shown to correlate with increased fatigue and cognitive weariness (Lang et al., 2022), and emotional exhaustion has been linked to subjective cognitive failures even in healthy adults (Podlesek et al., 2021). Similarly, depression is often accompanied by psychomotor slowing, low energy, and impaired concentration. Since the FACs targets central fatigue and cognitive symptoms—features also embedded within emotional distress syndromes—its convergence with the DASS is theoretically justified. While the DASS assesses these symptoms within broader affective contexts, the FACs isolates them, highlighting their shared foundation in mental and physical depletion.

It is important to note that, although the FACs showed strong correlations with the BAT and the DASS, there are conceptual distinctions between these instruments. The BAT and DASS are designed to assess broader psychological distress syndromes, such as burnout, depression, anxiety, and stress, which may encompass fatigue and cognitive symptoms as secondary features. In contrast, the FACs specifically targets the subjective experience of central fatigue and altered cognition, symptoms that often cut across diagnostic categories and may be present even in the absence of clinical depression or anxiety. By focusing on these core psychocognitive complaints, the FACs offers a more direct and nuanced assessment of brain fog and fatigue, capturing a symptom profile that is frequently underrepresented in general distress measures. This specificity enhances its potential utility in both clinical and occupational settings, where identifying and monitoring psychocognitive burden is essential.

The FACs demonstrated strong criterion-related validity through its significant and robust associations with burnout, depression, anxiety, and stress. Across all regression models, higher FACs scores consistently predicted greater psychological distress, with large effect sizes (β ranging from .64 to .80) and substantial proportions of explained variance (R^2 ranging from .41 to .64). These findings suggest that the FACs effectively captures meaningful variability in central fatigue and altered cognition symptoms and aligns closely with established measures of psychological distress, such as the BAT and the DASS subscales.

This discriminative power has important implications for both clinical and organizational settings. The FACs can serve as a useful screening tool, helping to identify individuals at risk of impaired functioning due to fatigue and cognitive complaints. In practice, elevated scores may prompt timely interventions, whether in healthcare or workplace environments. Moreover, the substantial effect sizes suggest that changes in FACs scores are not only statistically significant but also clinically relevant, making the instrument suitable for tracking symptom progression or response to treatment. By targeting central fatigue and cognitive difficulties often overlooked by general mood assessments, the FACs addresses a critical gap and proves to be a valid, reliable, practical tool for identifying psychocognitive burden.

Despite the importance of this study in validating a culturally adapted instrument to assess central fatigue and cognitive complaints in Portuguese-speaking populations, some limitations should be acknowledged. First, the use of a non-probabilistic convenience sample restricts the generalizability of the findings. Second, the cross-sectional design prevents any conclusions regarding the temporal stability of the FACs or causal inferences between symptoms and psychological distress. In this context, longitudinal studies are needed to assess test-retest reliability and the instrument's sensitivity to clinical changes or therapeutic interventions. Additionally, although the bifactor confirmatory model was selected based on theoretical considerations and the high correlation between the two latent dimensions, we acknowledge that alternative models were not tested in the present study. Future research should explore and compare these models to provide a more comprehensive understanding of the underlying structure of the FACs, ideally using cross-validation in independent samples. Another limitation of this study is the lack of information regarding participants' clinical status. Due to the length of the questionnaire and the intention to reduce participant burden, no data was collected on this topic limiting the ability to differentiate between clinical and non-clinical subgroups. Future studies should consider including such variables to better contextualize symptom severity and enhance the generalizability of findings to clinical populations. Lastly, as data were collected through an online survey, individuals with limited digital literacy or restricted internet access may have been less likely to participate. This potential sampling bias could have led to the underrepresentation of certain population groups, particularly older adults or individuals from lower socioeconomic backgrounds, thereby limiting the generalizability of the findings.

Considering the limitations mentioned above, future research should assess the scale's stability over time, the test-retest reliability, as well as its sensitivity to clinical change through repeated measurements in longitudinal or intervention-based designs. While the present study focused on a general population sample, future research should include clinical validation of the FACs in specific patient populations such as individuals with neurological or psychiatric diagnosis, as well as patients with fatigue and cognitive complaints. Testing the instrument's diagnostic utility and responsiveness to treatment in such contexts would enhance its clinical applicability and contribute to evidence-based intervention planning.

Conclusion

This study provides strong evidence for the reliability and validity of the Portuguese version of the Fatigue and Altered Cognition Scale (FACs). By demonstrating excellent internal consistency, robust convergent validity, and a clear ability to distinguish between individuals with varying levels of psychological distress, the FACs emerges as a valuable tool for both clinical and research contexts across several conditions. Although originally conceptualized as measuring two distinct domains—fatigue and altered cognition—our findings

support a primarily unidimensional structure, capturing a broader construct of psychocognitive exhaustion.

The availability of a culturally adapted version of the FACs in European Portuguese addresses a significant gap in the assessment of central fatigue and cognitive complaints, enabling more accurate symptom detection, better-informed interventions, and enhanced cross-cultural research. Future studies should build on these results by exploring the scale's utility in clinical populations and its sensitivity to change over time.

Author contributions

Carina Fernandes: Investigation, conceptualization, software, data collection, writing—review and editing; Pilar Baylina: Investigation, conceptualization, data collection, writing—review and editing; Fernando Barбора: Investigation, conceptualization, writing—review and editing; Carla Barros: Investigation, conceptualization, software, data collection, writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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Data availability statement

The corresponding author will provide data upon request

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