Title:

Translation and validation of the abbreviated Prefrontal Symptoms Inventory (PSI-20): a tool for assessing prefrontal symptoms in english-speaking populations

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Abstract:

This study introduces the translation and validation of the Prefrontal Symptoms Inventory (PSI) into English, aiming to provide an ecologically valid tool for assessing prefrontal symptoms in English-speaking populations in the United States. The prefrontal cortex (PFC) plays a crucial role in executive functions and other higher-order cognitive processes, with dysfunctions in this area associated with various cognitive, emotional, and behavioral changes. Despite the existence of established tools like the Dysexecutive Questionnaire (DEX), the PSI addresses limitations found in the literature, presenting a novel ecologically valid tool for assessing prefrontal symptoms. The current study, involving 226 English-speaking participants, lays a foundational step for validating the PSI for use in a new population. Semiconfirmatory factorial analysis, revealed a unidimensional structure, mirroring the Spanish version with robust fit indicators. Additionally, in assessing convergent validity, the PSI-20 exhibited high correlations with DEX scores and moderate correlations with Psychological Stress Scale (PSS) and General Health Questionnaire-12 (GHQ-12) scores. These findings align with previous reports, supporting the PSI-20's measurement of similar constructs related to prefrontal cortex activity and mental health components. The results of this study overall highlight the PSI's potential contribution to advancing prefrontal symptom evaluation in clinical and non-clinical settings.

Key words:

Assessment, ecological validity, linguistic validation, prefrontal cortex, prefrontal symptoms, psychometrics

Introduction

The human prefrontal cortex (PFC) is a brain region associated with Brodmann areas (BAs) 8 to BA14 and BA44 to BA47 responsible for a wide range of executive functions and other higher-order cognitive processes (Carlén, 2017; Friedman & Robbins, 2022). Due to its complex role in human cognition, the PFC is often subdivided into three functionally distinct regions (Fuster, 2001; Preuss & Wise, 2022): the orbitofrontal cortex (OFC), the ventromedial PFC (vmPFC), and the dorsolateral PFC (dlPFC). Alterations in areas of the PFC can manifest in the affected individual's life through cognitive, emotional and behavioral changes. Damage to the OFC has been associated with impulsive behavior and aggression (Davidson et al., 2000; Seabrook & Borgland, 2020), impairments in decision-making and social behavior (Anderson et al., 1999; Gore et al., 2023) and socially inappropriate behaviors (Tranel et al., 2002; Shi et al., 2023). Concerning deficits in affect, vmPFC damage has been associated with "…apathy, blunted affect, lack of empathy, irritability, and erratic emotion regulation" (Schneider & Koenigs, 2017; p. 86). Additionally, vmPFC lesions are also associated with deficits in the ability recognize and interpret emotions of others, a fundamental component of successful social interactions (Hiser & Koenigs, 2018). Finally, alterations in the dlPFC have been associated with a wide range of difficulties, notably "formulating goals, planning how to achieve them and carrying out the plans effectively" (Lezak, 1995). Other difficulties include disinhibition of automated responses, cognitive inflexibility, deficits in anticipating problems, rule learning, working memory, attention, and motivation (Mega & Cummings, 1994; Szczepanski & Knight, 2014). These failures in executive functioning are also referred to as dysexecutive syndrome (Baddeley, 1986; Ouerchefani et al., 2022).

Functional alterations such as those described above can have adverse effects in an individual's life and being able to assess them is crucial for clinical practice. Alterations related to deficits in the prefrontal cortex can be typically evaluated using tests such as the Stroop Test (Golden, 1978; Stroop, 1935), the Iowa Gambling Task (IGT; Bechara et al., 1994), the Wisconsin Card Sorting Test (WCST; Milner, 1963) or the Trail Making Test (Reitan, 1958). However, the tasks performed during these tests differ from real-world scenarios and have "little correspondence between the cognitive resources tapped in the examination condition, and those tapped in real-world ones" (Burgess et al., 1998, p. 547). Most task-based neuropsychological tests present patients with a single explicit problem to solve at a time, have short trials and initiation is specifically prompted. In a real-life scenario, where individuals would experience prefrontal symptoms, there would be a demand over longer periods of time that also requires the use of multiple domains and the management of cognitive resources to complete a task when faced with multiple competing demands (Shallice & Burgess, 1991;

Wilson et al., 1998). Based on these differences, ecologically valid neuropsychological tests have been developed to improve the assessment of prefrontal symptoms.

One of the questionnaires available and frequently used to assess prefrontal symptoms is the Dysexecutive Questionnaire (DEX) developed by Wilson et al. (1996) as a supplement to the Behavioral Assessment of the Dysexecutive Syndrome (BADS). More recently, a revised version has been developed (DEX_R; Simblett, et al., 2017). The DEX was developed with the objective of providing an ecologically valid assessment of the likely emotional, personality, motivational, behavioral and cognitive alterations commonly associated with the dysexecutive syndrome (Wilson et al., 1998), similar to the revised version. Two versions were developed for the 20-item questionnaire; one designed to obtain information through self-report and another designed to obtain information through a care-taker or family member of the patient. Statements are presented to the respondent and answers are scored in a five-point Likert scale ranging from “never” to “very often”. Analysis of the scores obtained in a clinical and non-clinical sample revealed a five-factor structure. The five factors found were related to inhibition, impaired abstract reasoning, executive memory, positive affect and negative affect (Burgess et al., 1998). An important element to note is that this questionnaire was originally developed for evaluation of prefrontal symptoms in patients with acquired brain damage but has also been used to study dysexecutive syndrome in other clinical populations such as patients diagnosed with schizophrenia (Evans et al., 1997; Orellana et al., 2022) or addictive behaviors (Pedrero-Pérez, Ruiz-Sánchez de León & Winpenny-Tejedor, 2015), and even non-clinical samples (Chan, 2001). However, there are a number of limitations associated with the DEX despite its widespread use in the literature and its significance in the clinical field. The revised version, DEX-R (37 items; Simblett et al., 2017) has been applied to different types of brain injuries (Bruijel et al., 2018; Lebely et al., 2024), as well as to behavioral addictions (Heffernan et al., 2024), and the general population (Heffernan et al., 2024; Wakely et al., 2022). However, there is not yet enough data to assess its contribution.

One of the limitations of the DEX questionnaire is that subsequent studies that have performed factorial analysis have found multiple factor solutions that are different to those proposed by its authors. Pedrero-Pérez, Ruiz-Sánchez de León and Winpenny-Tejedor (2015) presented in their review several studies that have analyzed the DEX’s factorial validity since its publication and found that different studies report anywhere between one and five factors. Another limitation of the DEX questionnaire is that it was originally developed for use in patients with acquired brain injuries and not in other conditions. Using a questionnaire developed for people with acquired brain injury posits a challenge since the existing surveys often include questions that refer to more severe symptoms that are often experienced by

patients with that specific condition but not by people with substance use disorder or others who may also experience prefrontal symptoms (Pedrero-Pérez, Ruiz-Sánchez de León, Morales Alonso et al., 2015; Shaw et al., 2015). Additionally, another limitation associated with the DEX is that previous studies have relied on restricted sample sizes, making it more difficult to draw definite conclusions on its psychometric properties beyond allowing to screen for prefrontal symptoms without having the ability to specify individual components (Pedrero-Pérez, Ruiz-Sánchez de León & Winpenny-Tejedor, 2015; Yang et al., 2018). Considering the questionnaire's psychometric limitations and its other issues, novel questionnaires have emerged to address these concerns, including the revised and expanded version of the DEX (DEX-R; Simblett et al., 2017).

The Prefrontal Symptoms Inventory (PSI, Ruiz-Sánchez de León et al., 2012) was originally developed in Spanish (*Inventario de Síntomas Prefrontales*) to evaluate the presence of prefrontal symptoms in people with substance use disorders and in a non-clinical sample. This questionnaire sought to offer an alternative to other surveys typically used in the field. Additionally, the authors of the PSI aimed to develop items that were phrased in simple and easy-to-understand terms to facilitate self-report. The questionnaire was developed based on the authors' own clinical experience focusing on behaviors that would be relevant and memorable to patients that reflect the three domains of human activity (cognition, emotion and behavior) as they relate to the three major prefrontal cortex syndromes (dorsolateral, ventromedial and orbital). The theoretical-clinical model framing the factors is similar to that present in other works, where the neuropsychological assessment tools commonly used to evaluate them can also be consulted (Ruiz-Sánchez de León et al., 2011; Tirapu-Ustárroz et al., 2011).

The final questionnaire proposed by the authors is composed of 46 items. Confirmatory factor analysis revealed that the items were distributed in three domains. The first domain grouped items referring to various executive issues. This domain was composed of items in three subscales: motivational issues, executive control issues and attentional issues. The second domain grouped items referring to problems in social behavior. This domain was composed of items in one subscale: social behavior issues. The final domain grouped items referring to emotional control. This domain was composed of items in one subscale: emotional control issues. Convergent validity analysis showed significant correlations between the motivational issues ($r = 0.52$, $p < 0{,}005$), executive control issues ($r = 0.56$, $p < 0.005$), attentional issues ($r = 0.53$, $p < 0.005$), social behavior issues ($r = 0.49$, $p < 0.005$) and emotional control issues ($r = 0.50$, $p < 0.005$) subscales of the PSI and the Spanish version of the DEX questionnaire (DEX-Sp, Pedrero-Pérez et al., 2011). Significant correlations, though more moderate, were

also found between the motivational issues ($r = 0.45$, $p < 0.005$), executive control issues ($r = 0.45$, $p < 0.005$), attentional issues ($r = 0.38$, $p < 0.005$), social behavior issues ($r = 0.29$, $p < 0.005$), and emotional control issues ($r = 0.39$, $p < 0.005$) subscales of the PSI and the Spanish version of the Perceived Stress Scale (PSS, Cohen & Williamson, 1988; EEP, Pedrero-Pérez & Olivar Arroyo, 2010).

The authors also proposed an abbreviated version of the questionnaire with 20 items. This questionnaire is comprised of the 4 items from each of the subscales. This questionnaire was proposed based on the data presented in the original paper and has been further validated in a study by Pedrero-Pérez, Ruiz-Sánchez de León, Morales Alonso et al. (2015). The sample of this study consisted of 602 participants diagnosed with substance use disorder and two non-clinical groups. One non-clinical group was recruited via social media (n=503) and the other non-clinical group was recruited by Neuropsychology graduate students (n=1257). Confirmatory factor analysis found that items were distributed in the same domains as in the original study. However, the subscales (trifactorial structure) were not replicated in the findings possibly due to the reduction in the number of items. Additionally, corrected item-test correlation showed considerable correlation in all items except for one item that showed a slightly weaker correlation (item 3). Internal consistency of the test as a whole was adequate (McDonald's $\omega=0.86$, Cronbach's $\alpha=0.86$, Carmine's $\theta= 0.85$), as well as the estimated consistency for each factor (0.87, 0.89, 0.87, respectively). Additionally, this study concluded that the 20-item PSI has good psychometric properties and can be used as a brief method to assess prefrontal symptoms.

Since its publication in 2012 the PSI has been used as a tool in various publications. For the 10-year anniversary of the PSI, Pedrero-Pérez and Ruiz-Sánchez de León (2022), published a review of 56 studies to assess the use of the PSI in the literature. The PSI has been utilized in multiple studies across different Spanish-speaking countries including Spain, Chile, Ecuador, Argentina, Cuba, Colombia and Venezuela. Additionally, a group in Brazil has translated and validated a Brazilian Portuguese version of the PSI that contains 16 items and has been used in two studies (Leite Ferreira et al., 2020, Leite Ferreira et al., 2023). The PSI is not only an ecologically valid questionnaire that has good psychometric properties. It is also a free and easily accessible tool. According to the review, the PSI has been used to assess prefrontal symptoms in a wide range of populations including but not limited to: people with neurological disorders such as acquired brain damage (Huertas-Hoyas et al., 2016), dementia (Ruiz-Sánchez de León et al., 2015), amyotrophic lateral sclerosis (Ruiz-Sánchez de León et al., 2019), chronic pain (Paz-Domingo et al., 2017), individuals that misuse information and communication technologies (Pedrero-Pérez et al., 2018; Cassú-Ponsati et al., 2021), people

with impulsive or compulsive personality traits (Pedrero-Pérez et al., 2021) and other personality disorders (Pedrero-Pérez et al., 2013), individuals with substance use disorder (Pedrero-Pérez et al., 2016; Terán-Mendoza et al., 2016; Rojo-Mota et al., 2017), the elderly (Leite Ferreira et al., 2020), women in rural environments (Valiente-Barroso et al., 2021), university students (Molina-Rodríguez et al., 2018) and the general population (Pedrero-Pérez et al., 2016). The PSI has also been used to study cognitive reserve (Pedrero-Pérez et al., 2014). Since the publication of the review, others studies have also used the PSI to assess individuals with multiple sclerosis (Cuerda-Ballester et al., 2023) and Alzheimer's disease (Leite Ferreira et al., 2023).

Despite the nature of the development of the PSI, its widespread use across various populations, the international interest that exists in this questionnaire and its established psychometric properties, the PSI has not yet been translated and validated in English. The objective of this study is to translate the Prefrontal Symptoms Inventory (PSI, Ruiz-Sánchez de León, 2012) into English and obtain its psychometric properties for an English-speaking population in the United States. This will offer an alternative to the more commonly used questionnaires available and increase the ease of accessibility of the assessment to an even larger population.

Methods

Participants

A non-clinical sample was recruited. The sample consisted of 231 participants. Participation was restricted to English speakers that were residing in the United States at the time of the survey. Preliminary analysis recommended the exclusion of 5 participants and further analysis was only performed on the remaining 226 participants. Information about their English levels was obtained along with other demographic data.

Inclusion/Exclusion Criteria

The following exclusion criteria were established based on the study design: Participants must (1) reside in the United States of America; (2) be at least 18 years old; (3) declare sufficient knowledge of the English language; (4) complete the evaluation protocol in its entirety; and (5) not have received psychiatric or neurological treatment at any time. Participants that did not meet all the exclusion criteria were excluded from the database.

Materials

There are two versions of the PSI, a complete and an abbreviated version, each consisting of 46 and 20 items, respectively (free download at https://doi.org/10.6084/m9.figshare.26935972 for the full version and https://doi.org/10.6084/m9.figshare.26936113 for the abbreviated one). The abbreviated version consists of selected items of the complete version. While all 46 items were presented, the 20-item PSI is the focus of this study (Table 1). The Spanish version of the survey was translated to English using the "Back Translation" technique (Shigenobu, 2007).

INSERT TABLE 1

The survey also included three additional questionnaires for analysis of convergent validity: the Dysexecutive Questionnaire (DEX, Wilson et al., 1996), the 10-item Perceived Stress Scale (PSS-10, Cohen & Williamson, 1988), and the 12-item General Health Questionnaire (GHQ-12, Goldberg & Williams, 1998. These questionnaires were added under the following premises: The DEX questionnaire measures the same issues as the PSI; the negative influence of perceived stress over executive function is well-known; and there is a known relationship between errors in daily life and psychological distress or psychopathological disorders. Therefore, strong correlations with the PSI-20 and the additional questionnaires were expected.

The Dysexecutive Questionnaire (DEX, Wilson et al., 1996) consists of 20 items describing behavior associated with dysexecutive syndrome. There are two versions, one for the respondent and one for a family member or care-taker. This study used the self-report version of the questionnaire. The items are scored individually on a five-point Likert scale (scores ranging from 0-4) rating the frequency of how often a behavior occurs from "never" to "very often". There is a lack of consensus in the literature regarding the factorial structure of the DEX, with the number of factors ranging from 1 (see Pedrero-Pérez, Ruiz-Sánchez de León & Winpenny-Tejedor, 2015) to 5 (see Luna-Lario et al., 2012), including all intermediate options. In this study, the unidimensional (total test score, Pedrero-Pérez, Ruiz-Sánchez de León & Winpenny-Tejedor, 2015) and bidimensional versions (Pedrero-Pérez et al., 2011) are utilized to obtain scores. The first factor, Disordered Behavior/Apathy, is obtained by adding the scores for items 1, 4, 6, 7, 8, 10, 11, 17, 18, and 19. The second factor,

Disinhibition/Impulsivity, is obtained from adding the scores from items 2, 3, 5, 9, 12, 13, 14, 15, 16, and 20.

The 10-item Perceived Stress Scale (PSS-10, Cohen & Williamson, 1988) is a self-report scale used to evaluate stress perceptions in regards to global and not event-specific stress. This scale is based on the original 14-item Perceived Stress Scale by Cohen et al. (1983) and seeks to evaluate "the degree to which respondents found their lives unpredictable, uncontrollable, and overloading" (p. 387). The questionnaire prompts the respondents to evaluate a series of prompts as they relate to their experiences in the last month. The items are scored on a five-point Likert scale (scores ranging from 0-4) rating the frequency of how often a behavior occurs from "never" to "very often". Scores are assigned in reverse order for the positively stated items in the scale. A total score is obtained from all items with higher scores indicating higher levels of perceived stress.

The 12-item General Health Questionnaire (GHQ-12, Goldberg & Williams, 1998) is a self-report scale that can help detect if a person is at high-risk of developing a psychiatric disorder or the presence of a psychological disturbance. The questionnaire prompts respondents to evaluate statements as they relate two their experiences in the past two weeks. There are multiple ways of scoring the items in this questionnaire. This study uses a four-point Likert scale (scores ranging from 0-3) rating different complaints. The questionnaire includes six positively stated items and six negatively state items. Items with different response options were presented separately within the same section to avoid confusion. All items are rated using the same four-point Likert scale. A total score is obtained from all items with higher scores indicating more psychological distress.

Procedure

The sample for this study was obtained through web-based recruitment. Participants were contacted and asked to fill out an online the survey that was constructed using Google Docs. Recruitment was done through various social media sites (LinkedIn, WhatsApp, Facebook, Instagram). Additionally, participants were asked to share the survey with other people after completion. Data was collected across two waves of active recruitment and it was finalized after surpassing 200 responses.

Participants were directed to the online questionnaire and were asked to respond to the questions as truthfully as possible. Participation in this study was voluntary and participants did not receive any compensation for participating. All participants were informed of their rights

and gave their consent to participate in the study, prior to starting the questionnaire. Participants were also informed that the personal data provided by them is protected and is subject to the guarantees provided in the Regulation 2016/679 (UE) of the European Parliament and Council of 27 April 2016. The study was approved by the Ethics Committee of the Doctoral Commission of the Faculty of Psychology of the Complutense University of Madrid.

Once the participants had given their consent, they were able to access the questions. The survey started by requesting relevant demographic information. Participants were asked to provide general information (sex, age, marital status, education level, citizenship) along with more specific information about their level of English. Participants were asked if English was their first language, if they responded “no” they were prompted to select their first language from a list of the five most frequently spoken languages other than English in United States’ homes according to a report published by the U.S. Census Bureau (2022). The options included Spanish, Chinese, Tagalog, Vietnamese, Arabic and a field for free entry. Additionally, participants were asked to rate their level of English proficiency using a simplified version of Interagency Language Roundtable (ILR) scale. This scale was proposed by the ILR, a United States Federal interagency organization, to qualify proficiency levels in a standardized manner within government agencies with levels ranging from “No proficiency” to “Native or bilingual proficiency” (Interagency Language Roundtable, n.d.). Participants were also asked to declare if they had received psychiatric or neurological care at any point in their life.

After filling out their demographic data, the survey proceeded to show each of the questionnaires in separate sections. The questionnaires were presented in the following order: Prefrontal Symptoms Inventory, the Dysexecutive Questionnaire, the Perceived Stress Scale and the 12-item General Health Questionnaire. Each section was preceded by specific instructions pertaining to the scales of each set of questions. Participants had to respond to all questions within a section in order to move on to the next one.

Data Analysis

First, outliers were detected through the analysis of atypical scores using the Mahalanobis distance test ($p<0.001$). A simulation of 500 random submatrices was performed using the Bootstrap technique to determine the confidence intervals of the estimators. Next, a descriptive analysis of the sample and the items was conducted. The fit of the data to multivariate normality was examined using the method proposed by Mardia (1970) and a

polychoric correlations matrix was configured. The suitability of the matrix for factor analysis was assessed using Bartlett's statistic and the Kaiser-Meyer-Olkin (KMO) test. Optimal implementation of parallel analysis (Lorenzo-Seva et al., 2011) was used to determine the number of factors to retain, followed by estimators of unifactorial solution quality (Ferrando & Lorenzo-Seva, 2018): Unidimensional Congruence (UniCo), with optimal values above 0.95, and Mean of Item Residual Absolute Loadings (MIREAL), with optimal values below 0.30. Given the small size of the sample, applying a confirmatory factor analysis on a different sample or of obtaining two independent subsamples was not possible. Semi-confirmatory factor analysis (Lorenzo-Seva & Ferrando, 2023) is a procedure that allows for easy derivation of a test statistic to evaluate the fit of the model data from the value of the least fit function when using the unweighted least square (ULS) method, which is appropriate for the data of the present study. LOSEFER correction was applied (Lorenzo-Seva & Ferrando, 2023) to obtain the following goodness of fit indicators: Root Mean Square Error of Approximation (RMSEA), acceptable below 0.08, Non-Normed Fit Index (NNFI), Goodness of Fit Index and Adjusted Goodness of Fit Index, all acceptable above 0.90 and optimal above 0.95. Replicability of the test in future samples was examined using the Generalized H Index (G-H; Hancock & Mueller, 2000), acceptable above 0.80. The quality of the unifactorial solution was assessed using three statistics (Ferrando & Lorenzo-Seva, 2018): Factor Determinacy Index (FDI) and Expected Percentage of True Differences (EPTD), both acceptable above 0.90, EAP marginal reliability, acceptable above 0.80, and Sensitivity Ratio (SR), acceptable above 2. Internal consistency of the scale was estimated using McDonald's ordinal ω and Standardized Cronbach's α, acceptable between 0.70 and 0.95. Pearson's r was used for correlations, applying Bonferroni correction for multiple correlations. All analyses were performed in SPSS 25 and FACTOR 12.04.05 (https://psico.fcep.urv.cat/utilitats/factor/).

Results

The Mahalanobis test was applied ($p<0.001$) which suggested the exclusion of 5 participants (2.2%). The remaining analyses were conducted on a sample of n=226. Demographic characteristics of the participants, after exclusion of the 5 participants that were outliers as detected through the analysis of atypical scores using the Mahalanobis test, can be found in Table 2.

INSERT TABLE 2

Descriptive Analysis of the Sample

A descriptive analysis was conducted to provide an overview of key characteristics within the sample. Table 3 shows the descriptive statistics of the 20 items in the abbreviated PSI.

INSERT TABLE 3

Exploratory Factor Analysis

Firstly, it was examined whether the data matrix conformed to multivariate normality. The Mardia test indicated a lack of fit ($p<0.05$). This result prompted the configuration of a polychoric correlations matrix that met the adequacy criteria for factor analysis (KMO=0.80; Barlett statistic=2504.1; $p<0.001$).

Subsequently, an optimal implementation of parallel analysis was done. This analysis yielded a 2-factor solution which explains 40.6% (eigenvalue 7.25) and 10.7% (eigenvalue 1.43) of variance, respectively. However, upon inspection of the item loads for both factors, an inconsistent item distribution was observed, particularly in a second factor where items loaded considerably on both factors. The ratio between the variance explained by the first factor and the second was 3.8, very close to the theoretical value of 4 required to consider the existence of a second independent factor. Hence, a possible unifactoriality of the scale was explored. The following statistics were applied: UniCo=0.92 (CI 0.88 – 0.96), which is slightly below 0.95, the cutoff value, although still within the confidence interval; MIREAL=0.25, which is adequate as it is below 0.30, the cutoff value. Therefore, the data suggest that the data can be treated as essentially unidimensional.

Semi-confirmatory Factorial Analysis

Given that the solution suggested by the exploratory factorial analysis was not clear, a second method was developed. The hypothesis of unidimensionality was tested and fit indicators were applied and proved adequate in all cases: RMSEA=0.076 (CI95% 0.074 – 0.079), NNFI=0.96 (CI95% 0.95 – 0.97), CFI=0.962 (CI95% 0.95 – 0.97), GFI=0.94 (CI95% 0.89 – 0.95), AGFI=0.93 (CI95% 0.87 – 0.94). Test replicability was studied in different samples, revealing that the test measures a well-defined latent variable, and that similar results could be obtained if it was applied to new samples (H latent=0.93 (CI95% 0.91 – 0.94); H observed=0.88 (CI95% 0.85 – 0.90). The quality of the unifactorial solution was assessed, and all indicators were

adequate: FDI=0.96, EAP=0.93, SR=3.65, and EPTD=94.1. The unifactorial solution showed adequate internal consistency: McDonald's ordinal ω=0.91; Standardized Cronbach's α=0.91.

Convergent Validity

Table 4 displays Pearson correlations between PSI-20 scores and the complementary scales of the DEX (and its subscales), the PSS, and the GHQ-12. All correlations were significant after applying Bonferroni correction for multiple correlations.

INSERT TABLE 4

Discussion

Analysis of the data collected establishes that the translated 20-item Prefrontal Symptoms Inventory (PSI) is a valid assessment tool for evaluating prefrontal symptoms in an English-speaking population. The study examined the correlation of the individual items with the questionnaire overall and this revealed a high degree of internal consistency. Exploration of the factorial structure of the translated questionnaire revealed that it maintained the same structure as the original Spanish version, emphasizing its robustness and cross-cultural applicability. The study further demonstrates the questionnaire's high replicability and its ability to measure related constructs as in other established questionnaires in the field. This analysis suggests that the PSI-20 is a valuable instrument for ecological assessment of prefrontal symptoms in an English-speaking population.

All of the items in the abbreviated survey demonstrated a considerable correlation with the questionnaire as a whole (r_{it}>0.3) once removed; with only item 20 showing some weakness (r_{it}=0.25), still remaining within the acceptable range. The exploratory factorial analysis yielded a two-factor solution that was found to be inadequate, as an inconsistent second factor emerged. However, the bifactorial solution was very close to the thresholds that would allow for the existence of a second independent dimension. All unidimensionality estimators were found to be optimal.

When exploratory factorial analysis does not provide a clean solution, it is necessary to use a different method. Therefore, a semi-confirmatory factorial analysis (Lorenzo-Seva & Ferrando, 2023) was conducted using the sample while referencing the unifactorial structure found in previous studies (Pedrero-Pérez, Ruiz-Sánchez de León, Morales Alonso et al., 2015). This analysis aimed to elucidate the latent structure of the PSI-20 within an English-speaking population. The results of the analysis suggested a unidimensional structure for the abbreviated PSI, meaning that the items collectively tap into a single underlying construct related to prefrontal symptoms. This finding is consistent with the idea that the PSI-20 measures a well-defined latent variable termed prefrontal symptomatology.

The fit indicators consistently demonstrated the reliability of the English version of PSI-20, affirming its internal consistency. The high values for McDonald's ordinal ω and Standardized Cronbach's α underscore the robustness of the scale in measuring the same underlying construct of prefrontal symptoms. Additionally, the high replicability indices obtained in the analysis indicate that the English version of the questionnaire is likely to yield consistent results in future studies and across various English-speaking populations in the United States when assessing prefrontal symptomatology.

In evaluating convergent validity, the present study explores the questionnaire's capacity to align with other established measures. Notably, high correlations were found between the scores of PSI-20 and the total score for the DEX questionnaire. More moderate correlations were also found between the scores of the PSI-20 and the scores in the PSS and the GHQ-12. These findings reinforce what has been previously reported and provide further support that the PSI-20 is measuring similar constructs. In the case of the DEX and the PSS, the constructs being those related to prefrontal cortex activity and in the case of the GHQ-12 those related to the mental health components of prefrontal symptoms.

The main advantage of the PSI-20 over the DEX is that the items are formulated with a focus on aspects of daily life, making it easier to apply to clinical and subclinical populations, and even to the general population. Additionally, the PSI-20 has demonstrated excellent psychometric properties in studies with modest samples as well as in large population studies (e.g., n=4704; Pedrero-Pérez & Ruiz-Sánchez de León, 2019). Furthermore, it provides three dimensions—executive, emotional and social—compared to the apparent unidimensionality of the DEX shown in extensive population studies (Pedrero-Pérez, Ruiz-Sánchez de León & Winpenny-Tejedor, 2015). The PSI-20 has also shown evidence of convergent and divergent validity with major neuropsychological assessments (Pedrero-Pérez et al., 2016) and has

been successfully tested in multiple clinical populations, as mentioned in the introduction of this paper. Lastly, and importantly, it is a free and easily accessible tool for researchers and clinicians.

Even though the use of the PSI has spread through Spain and many Latin American countries (Pedrero-Pérez & Ruiz-Sánchez de León, 2022), the DEX is still the gold standard for the measurement of the so-called dysexecutive syndrome. It is possible that the reputation of the questionnaire and its authors encourage the use of the DEX over the PSI. Nevertheless, the PSI is expected to be welcomed, not only in English-speaking countries, but in many other parts of the world. In addition to the Portuguese that is being used in Brazil, the authors are currently working on the validation of the French version of the inventory,

The main limitation of this study is its small sample size. While the sample meets the criteria of 10 subjects per item, the results of the factorial analysis cannot be considered stable. Due to this, an increase in sample size could slightly modify the results. However, given the current findings, it is likely that it would improve the results obtained in the unifactorial statistics. A second issue is the online sampling procedure, which does not allow control over the participants. It is a growing sampling method that enables obtaining large samples but is not without its problems (Evans & Mathur, 2018). Consequently, the sample included participants who did not have a perfect command of the English language, which undoubtedly could have influenced the lower data consistency. Additionally, the academic background of participants was skewed towards higher education and university studies, making it necessary for future studies to consider applying the assessment to samples with greater variability in academic and professional backgrounds. Moreover, the sample does not allow for establishing norms to facilitate the interpretation of results in clinical terms, and the study design did not consider divergent validity, which should be explored in future studies. Lastly, one might argue that evaluating impairments from the subjective experience of the affected person is inherently unfeasible. Indeed, it is paradoxical to inquire about anosognosia or deficits in self-awareness from the participant. However, items aimed at assessing these aspects were eliminated from the first version of the instrument due to their abnormal behavior (Ruiz-Sánchez de León et al., 2012). On the other hand, in the work by Ruiz-Sánchez de León et al. (2015), it was found that individuals who tend to overestimate their difficulties, such as patients with early multiple sclerosis, also overestimate their difficulties on the PSI-20. The procedure in that case included a version of the PSI-20 for informants from the patient's family, which is intended to be validated in the future in English-speaking populations as well.

The findings of this preliminary study, despite the inherent limitations associated with a restricted sample size, demonstrate promising potential for the future validation of the Prefrontal Symptoms Inventory (PSI) for use by an English-speaking population. To address these limitations, future research should focus on expanding the sample size, increasing sampling variability, and further refining the findings of this study. Future studies should also obtain the psychometric measures for the 46-item version of this questionnaire. These steps are crucial for establishing the reliability and validity of the translated questionnaire and ensuring its applicability in diverse contexts (general population, different clinical populations). Additionally, this study focused on validating the PSI-20 in an English-speaking population in the United States. In order to increase accessibility to this questionnaire, future research should seek to expand the sample to other English-speaking countries.

Conclusion

In conclusion, this study lays the foundation for the development of updated assessment tools for prefrontal symptoms. The development and validation of the Prefrontal Symptoms Inventory (PSI) in English represent a crucial step in addressing the existing gap in the availability of ecologically valid tools for evaluating PFC-related cognitive, emotional, and behavioral changes that are not occurring necessarily in the context of brain injury and can be used in both clinical and non-clinical populations. Based on the findings of this study, this questionnaire seems to also be a valuable tool for assessing prefrontal symptomology in an English-speaking population. The psychometric measures obtained highlight the strength of the PSI in assessing similar concepts to established measures and demonstrate the potential that there is in more recently developed tools to further the field.

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Table 1

Items in the English version of the Prefrontal Symptoms Inventory

#CV	# AV	Item
1	1	I have trouble starting an activity. I lack initiative.
2	2	I find it hard to concentrate on something.
3	3	I cannot do two things at the same time (for example, prepare food and talk).
4	4	I laugh or cry too easily.
5	5	I get very angry over insignificant things. I get irritated very easily.
6		I have little ability to solve problems.
7		I mix up some episodes of my life. I get confused when trying to put them in order.
8		I am late for my appointments.
9		I find it hard to adapt to changes in my routine.
10		I speak to strangers as if I knew them.
11		I get distracted easily.
12	6	I find it hard to change the subject in conversations.
13		Some things make me too angry and I lose my temper.
14	7	I am lethargic, as if asleep.
15	8	I have difficulty making decisions.
16		I speak out of turn, interrupting others in conversations.
17	9	I forget that I have to do things but I remember them when somebody reminds me.
18		I find that time passes very quickly.
19	10	I do not do things until someone tells me that I have to do them.
20	11	I have difficulties following the plot of a film or a book.
21	12	I have difficulty thinking or planning ahead.
22	13	I can go from laughter to tears easily.
23		I neglect my personal hygiene.
24		Things do not excite me. I am not interested in any activity.
25		I take risks just for the pleasure of it even if I get in trouble for it.
26		I find it hard to change plans when things are going wrong.
27	14	I tell inappropriate jokes in inappropriate situations.
28		I behave as if other people did not exist.
29	15	I find it hard to get going. I lack energy.
30		I repeat the same mistakes. I do not learn from experience.
31		I struggle to think clearly when there is noise in the street.
32	16	I find it hard to plan things in advance.
33		I touch or hug people even if I hardly know them.
34		I slam doors, hit furniture, or throw things when I get angry.
35		I struggle to find the solution to problems.
36		I do things impulsively.
37	17	I mention very personal issues in front of others.
38		I want to do some things, but then, I do not do them.
39	18	I do or say embarrassing things.

40		I get confused when I am doing things in order.
41	19	I have emotional outbursts without an important reason.
42		I have trouble understanding what other people mean.
43		I tend to act in a sensual way in front of others. I flirt too much.
44		I do or say things I should not do when I am with others.
45	20	I make inappropriate sexual comments.
46		I am indifferent toward everything. I do not care about things.

Note. #CV: item number in complete version of PSI, #AV: item number in abbreviated version of PSI.

Table 2

Demographic Characteristics of Participants

		n	%
Sex	Female	137	60.6
	Male	89	39.4
Age (Mean ± Standard Deviation)	43.97 ± 14.2 years old		
Age Range	18-75 years old		
Age Group	18-29	56	24.8
	30-39	21	9.3
	40-49	48	21.2
	50-59	73	32.3
	60-69	26	11.5
	70-75	2	0.9
Highest Level of Education Achieved	None or Elementary School	0	0.0
	Middle school	0	0.0
	High school	22	9.7
	Associate's Degree	23	10.2
	Bachelor's, Master's or Doctorate Degree	177	78.3
	Other	4	1.8
United States Citizenship	Yes	173	76.5
	No	53	23.5
English as First Language	Yes	92	40.7
	No	134	59.3
English Proficiency Levels	No Proficiency	0	0.0
	Elementary Proficiency	1	0.4
	Limited Working Proficiency	4	1.8
	Professional Working Proficiency	30	13.3
	Full Professional Proficiency	76	33.6
	Native/Bilingual Proficiency	115	50.9

Table 3

Descriptive Statistics of PSI-20 items and of the unifactorial solution

Item	Mean (CI95%)	Variance	Skewness	Kurtosis (Zero centered)	r_{it}	Factor load	Communality
1	1.20 (1.03 - 1.37)	1.00	0.46	-0.41	0.58	0.66	0.43
2	1.45 (1.27 - 1.62)	1.09	0.27	-0.49	0.64	0.72	0.51
3	0.99 (0.79 - 1.18)	1.28	1.02	0.18	0.30	0.37	0.14
4	1.35 (1.14 - 1.55)	1.40	0.54	-0.64	0.38	0.38	0.14
5	1.13 (0.96 - 1.30)	1.00	0.71	0.03	0.54	0.60	0.36
6	1.01 (0.87 - 1.15)	0.69	0.64	0.22	0.40	0.44	0.19
7	0.86 (0.69 - 1.02)	0.95	1.01	0.52	0.56	0.68	0.46
8	1.21 (1.02 - 1.40)	1.23	0.60	-0.41	0.70	0.78	0.61
9	1.23 (1.06 - 1.40)	0.97	0.40	-0.49	0.61	0.69	0.47
10	0.72 (0.59 - 0.86)	0.64	1.02	0.91	0.51	0.62	0.39
11	0.61 (0.49 - 0.73)	0.53	0.96	0.25	0.36	0.47	0.22
12	0.74 (0.60 - 0.87)	0.66	0.77	-0.33	0.55	0.68	0.46
13	0.80 (0.62 - 0.97)	1.03	1.18	0.63	0.35	0.36	0.13
14	0.47 (0.36 - 0.59)	0.44	1.18	0.52	0.45	0.59	0.34
15	0.97 (0.79 - 1.14)	1.03	0.86	0.03	0.66	0.75	0.56
16	0.77 (0.62 - 0.91)	0.68	0.74	-0.38	0.51	0.66	0.43
17	0.85 (0.69 - 1.00)	0.84	0.76	-0.29	0.47	0.54	0.29
18	0.81 (0.64 - 0.97)	0.93	1.01	0.22	0.65	0.77	0.59
19	0.47 (0.34 - 0.59)	0.55	1.63	2.12	0.52	0.60	0.36
20	0.18 (0.10 - 0.25)	0.21	2.62	6.22	0.25	0.41	0.17

Note. CI 95%: Confidence Interval at 95%, r_{it}: Corrected item-total correlation

Table 4

Bivariate Pearson correlations between the total scores of the PSI-20 with those of complementary tests (DEX, PSS and GHQ-12)

	PSI-20 Total Score
DEX Total Score	0.83
DEX Disordered Behavior/Apathy	0.84
DEX Desinhibition/Impulsivity	0.73
PSS Score	0.68
GHQ-12 Score	0.58

Note. All correlations are significant after Bonferroni correction ($p < 0.0002$)