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Self-reported executive function, and not performance-based measures, strongly associates with symptoms of premenstrual syndrome/premenstrual dysphoric disorder

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ABSTRACT

Introduction. Premenstrual syndrome/premenstrual dysphoric disorder (PMS/PMDD) may be neuropsychologically understood as impairments of executive functions (EF), since these are related to the regulation of complex behavior and cognition. **Objective.** To test the utility of self-report of EF versus performance-based measures, for the understanding of PMS/PMDD, and to analyze interactive effects between symptoms of these pathologies and EF on daily-life functionality. **Method.** Mexican women were recruited through non-probabilistic procedures. The Premenstrual Symptoms Screening Tool (PSST) was used to determine severity of symptoms and functional impairment in daily-life activities, and the Behavioral Rating Inventory of Executive Functions-Adults (BRIEF-A) (short Spanish-translated version) adapted to collect information on EF during luteal versus follicular phases. Performance was evaluated with Stroop, Trail Making Test and Letter-Number Sequencing. **Results.** A total of 157 were analyzed. Three groups were formed: No diagnosis (n = 78); PMS (n = 67) and PMDD (n = 12). Between-group differences were observed for both BRIEF-A-Luteal and BRIEF-A-Follicular. Bivariate correlations between these measures and the PSST were found, with double the magnitude relative to BRIEF-A-Luteal. Only two indicators of performance-based measures were weakly associated to the PSST. The regression model showed high multicollinearity between self-reported EF and PMS/PMDD symptoms, and no interaction was found. **Discussion and conclusion.** Self-report probed a better association than based-performance tests for the assessment of EF in PMS/PMDD. EF deficits and PMS/PMDD symptoms, particularly during luteal phase, may be as closely link as to allow for the consideration of these diagnoses as partial forms of dysexecutive syndrome.

Keywords: Premenstrual dysphoric disorder, premenstrual syndrome, executive function, BRIEF-A, PSST.

RESUMEN

Introducción. El síndrome premenstrual/trastorno disfórico premenstrual (SPM/TDPM) pueden entenderse neuropsicológicamente como alteraciones de las funciones ejecutivas (FE), ya que éstas permiten la regulación del comportamiento complejo y la cognición. **Objetivo.** Evaluar la utilidad del autorreporte de las FE versus pruebas de desempeño para comprender el SPM/TDPM, y analizar los efectos interactivos entre los síntomas de estas patologías y las FE sobre el funcionamiento diario. **Método.** Mujeres mexicanas fueron reclutadas por medio de procedimientos no probabilísticos. El Instrumento de Detección de Síntomas Premenstruales (PSST) se utilizó para determinar la gravedad de los síntomas y el deterioro funcional en las actividades de la vida diaria, y el Inventario de Evaluación Conductual de la Función Ejecutiva-Adultos (BRIEF-A) (versión breve traducida al español) para recopilar información sobre EF durante las fases lútea versus folicular. Se emplearon también las pruebas de desempeño: Stroop, Trail Making Test y Secuencia de Letras y Números. **Resultados.** Se analizó un total de 157 participantes. Se formaron tres grupos: sin diagnóstico (n = 78); SPM (n = 67) y TDPM (n = 12). Se observaron diferencias entre los grupos para BRIEF-A-Lútea y BRIEF-A-Folicular. Se encontraron correlaciones bivariadas entre estas medidas y el PSST, con el doble de magnitud en relación con BRIEF-A-Lútea. Solo dos indicadores de medidas basadas en el desempeño mostraron una asociación débil con el PSST. El modelo de regresión mostró alta multicolinealidad entre el autorreporte de FE y SPM/TDPM, y no se encontró la interacción esperada. **Discusión y conclusión.** El autorreporte mostró una mejor asociación que las pruebas de rendimiento para la evaluación de FE en SPM/TDPM. Los déficits de EF y los síntomas de SPM/TDPM, particularmente durante la fase lútea, pueden estar tan estrechamente vinculados como para permitir la consideración de estos diagnósticos como formas parciales de síndrome disejecutivo.

Palabras clave: Trastorno disfórico premenstrual, síndrome premenstrual, funciones ejecutivas, BRIEF-A, PSST.

INTRODUCTION

Premenstrual dysphoric disorder (PMDD) is considered a severe form of premenstrual syndrome (PMS), characterized by physical (e.g., breast fullness, weight gain), affective (e.g., depression, anxiety), cognitive (e.g., decreased concentration), and behavioral (e.g., sleep disturbances and impulsivity), all of them symptoms that produce a significant impairment in the daily functioning of women. These symptoms manifest themselves during the luteal phase of the menstrual cycle, peak two days before menstruation begins, and diminish within the first days of menstruation (Hantsoo & Epperson, 2015; Ryu & Kim, 2015).

As with other depressive disorders, PMS/PMDD may be neuropsychologically understood as impairments of executive functions (EF), since these are related to regulation of complex behavior and cognition and thus underly or are closely related to the dynamics of most psychopathologies (Snyder, Miyake, & Hankin, 2015). PMS/PMDD-associated EF deficits may be addressed from a neuropsychological perspective in two ways: (a) mild-to-moderate impairments evidenced by neuropsychological testing are suspected due to corresponding brain anomalies (e.g., frontal lobe dysfunction to regulate limbic responses); (b) symptoms of the disorder may be understood as affective and behavioral manifestations of cognitive deficits (e.g., rumination of negative thoughts as cognitive inflexibility and deficits in updating of working memory, impulsivity as poor inhibition of response, anxiety as excessive attentional bias toward threat).

A review (Souza, Ramos, Hara, Stumpf, & Rocha, 2012) reported mixed evidence of poor performance associated to PMS/PMDD in tasks of motor skills, processing speed, complex attention, and verbal/visual memory, but no significant deficits in performance of typical EF tasks involving verbal fluency, cognitive flexibility or planning. However, some of the reported impaired cognitive functions (if not all of them) in this review are more or less related to EF as in the clear cases of complex attention and processing speed. More recent original research also points to possible links between severity of PMS/PMDD, poor inhibition of response, and impulsivity (Yen et al., 2011), working memory and attention (Slyepchenko et al., 2017), which are all particular expressions of EF.

Most of these studies employ based-performance neuropsychological measures. With the exception of the study by Yen et al. (2011), to our knowledge, none of the studies uses formal measures of self-report EF, despite the fact that these may provide more ecologically valid information (Meltzer et al., 2017), and often are equally or better associated to other clinical variables than performance-based measures (Buchanan, 2016; Jarrett, Rapport, Rondon, & Becker, 2017; Løvstad et al., 2012). Because of this, self-reports may be useful to advance the understanding of depressive symptoms as manifestations of EF impairment, as we stated above. In any case, both sources of information are recommended to be collected when assessing any neurocognitive disorder in order to improve diagnostic accuracy (American Psychiatric Association, 2013).

Besides, to our knowledge, all the studies relating symptoms of PMS/PMDD and EF do so by considering the latter as independent predictors of the former, bypassing any possible interaction that might explain variations in clinical outcomes. Some studies have shown that analyzing the interaction between EF and other predictors of interest actually improves the predictive capacity of the predictors in a regression model in accordance to theoretical assumptions (Bierman, Nix, Greenberg, Blair, & Domitrovich, 2008; Hall, Zehr, Paulitzki, & Rhodes, 2014; Sprague, Verona, Kalkhoff, & Kilmer, 2011).

The objectives of our study were: 1. to test for significant linear associations between severity of PMS-PMDD symptoms and EF measured by performance-based tasks and by self-report (retrospection of behavior and cognition during luteal phase and follicular phases), and to compare the magnitude of the associations between these measures; 2. to test for interactive effects of severity of PMS-PMDD symptoms, and both performance-based and self-reported EF as predictors of clinical functionality; 3. to compare EF between three groups: No diagnosis, PMS, and PMDD, aiming to provide more usable clinical information.

METHOD

Study design

Case-control study.

Subjects

We recruited women residing in the Mexican Republic (Mexico City, State of Mexico, Cuernavaca, Cancun, and Veracruz) from January to November 2019. Inclusion criteria were: age between 18 and 49 years (since it has been reported that Mexican women, on average, start menopause around this age [Torres Jiménez & Torres Rincón, 2018]), ability to read and write, comprehension and signing of informed consent.

Recruitment was structured in two paralleled procedures: 1. by chain-referral sampling in the general population; 2. by case-sampling based on referral from a private gynecologist (see *Procedure*). Typical studies on the subject-matter analyzed samples with 20-30 women diagnosed with PMDD or PMS (Slyepchenko et al., 2017; Souza et al., 2012); we aimed to gather a sample with similar sizes for each diagnostic subgroup.

Measurements

Demographic questionnaire

It included questions regarding age, degree of education, current phase of the menstrual cycle, current use of any oral contraceptive, and lifetime neuropsychiatric history (any formal diagnosis provided by a mental health professional).

Premenstrual Symptoms Screening Tool (PSST)

This is a self-report questionnaire that aims to identify the presence of PMDD and its severity. It is composed of 14 items listing a comprehensive set of premenstrual symptoms based on the DSM-IV criteria. Individuals are asked to respond to the question "Do you experience some or any of the following premenstrual symptoms which start before your period and stop within a few days of bleeding?," rating their answer in a four-point Likert scale ranging from "Not at all" = 0 to "Severe" = 3. A score from 0 to 42 is calculated with the 14 items, with higher scores indicating a more severe symptomatology. For this study, diagnoses of PMDD and PMS were obtained by following the procedure described by the authors of the scale (Steiner, Macdougall, & Brown, 2003).

The PSST also evaluates the impact of the PMS/PMDD symptoms in five different areas of the individual's general functioning (productivity at work, relationships with co-workers, family relationships, social activities, and housework). We used the sum score of these items as indicator of functionality in daily living, to use in the main regression analysis as outcome variable.

This instrument was originally validated using Fisher's exact test for comparison of three groups: PMDD, Moderate-to-Severe PMS, and No/Mild PMS, regarding the presence of symptoms like depressed mood, anxiety/tension, tearfulness, anger/irritability, decreased interest in work, etc. These symptoms are usually associated to the disorder and, as expected, showed higher percentages in women with PMDD (Steiner et al., 2003).

The PSST has been translated and tested cross-culturally (Câmara, Köhler, Frey, Hyphantis, & Carvalho, 2017); the validation in Brazil population, for example, showed a Cronbach's $\alpha = .91$ and $r = .86$ for test-retest reliability. Since no Mexican validation was available at the time we designed the study, we adapted the scale using a simple back-translation process in which one PhD in Psychology firstly translated the instrument to the Spanish, and then a second PhD in Psychology back-translated it to the English language to test for discrepancies. The final result of this process was also compared to the official DSM-IV Spanish translation (American Psychiatric Association, 2000). Since the sentences used in the PSST are rather simple and direct, no discrepancies were found.

Behavior Rating Inventory of Executive Functioning, Adults (BRIEF- A) – Short Version

This inventory assesses EF in everyday life (Roth, Lance, Isquith, Fischer, & Giancola, 2013). We used the 17 items of a brief Spanish-translated version of the scale (Basuela-Herreras, 2016). The BRIEF-A displays a list of statements concerning difficulties related to the control of goal-oriented behavior and cognition, and asks the respondent to evaluate her own behavior according with the options: "Never" = 1 to "Often" = 3. A total score can be computed, with values scores indicating more severe dysexecutive symptoms; also, we computed scores for three factors: Emotional Regulation, Metacognition, and Behavioral Regulation, following the factor analysis performed by Roth et al., 2013 with the complete form of the BRIEF-A.

To discriminate between the expression of EF during luteal phase versus follicular phases (menstrual, folicular, or ovulation), we adapted the BRIEF-A into two forms changing the instruction of the scale as follows: (a) "Select the response option that is closest to what you usually experience a week before your period, ending during the first days of bleeding" for the luteal phase; and (b) "Select the response option that is closest to what you usually experience in the rest of the month" for the follicular phases.

Stroop Test

This test operationalizes inhibition of response, according to the EF model by Friedman and Miyake (2017). We used a version which is included in a more extensive battery for assessment of EF adapted to the Mexican population (Flores Lázaro, Ostrosky Shejet, & Lozano Gutiérrez, 2012). For this study, we used number of errors (Stroop or non-Stroop) and total time to complete each form as indicators of performance, with longer time and greater number of errors corresponding to higher difficulty in the performance.

Trail Making Test

This test operationalizes cognitive shifting, according to the EF model by Friedman and Miyake (2017). The test is composed of two forms A (sequential tracking of numbers) and B (alternated tracking of numbers and letters). In the first one, the subject must connect numbers from 1-25 without lifting the pencil (Tombaugh, 2004). Total time and sequencing errors were taken as indicators of performance as in the Stroop test described above.

Letter-Number Sequencing

This test operationalizes cognitive updating (working memory) according to the EF model by Friedman and Miyake (2017). We used the version included in the Wechsler Intelligence Scale-IV adapted for Mexican population (Wechsler, Meng, Martínez, & Zhu, 2014). The task consists on progressive series of alternated numbers and letters that the participant is asked to repeat after the evaluator has said them out loud. Correct repetition of each series is taken as a point and a total score is calculated to estimate performance.

Procedure

For the chain-referral sampling, we firstly approached to female acquaintances, then to their acquaintances, and lastly to acquaintances of school peers of the authors of this study. For the case sampling, a private gynecologist provided general information of the study to patients whom he had previously identified as possible cases of PMDD; if interested, he provided us with their contact information, we telephoned them, provided more detailed information about the study and scheduled an appointment. Informed consent was detailed to all potential participants and we ensured comprehension before asking them to sign up.

All the measures were administered in a single session that lasted approximately 20-30 minutes in the following order: demographic questionnaire, PSST, BRIEF-A for luteal phase and for follicular phases, Stroop test, Trail Making Test and Letter-Number Sequencing. Following recommendations to avoid common biases in behavioral research (Mackenzie & Podsakoff, 2012), we encouraged our participants to carefully reflect on their answers to the self-reports.

Statistical analysis

Flow of participants was described from recruitment to total analyzed sample. Descriptive analysis was performed using mean and standard deviation for numerical variables, and frequency and percentage for categorical variables. Pearson product-moment correlations were run to test for linear associations between total score of the PSST, scores (total and by factors) of the two forms of the BRIEF-A (EF during luteal and follicular phases), and scores of the performance-based tasks. Tests of statistical differences (Student's *t*, ANOVA or chi-squared) of EF relative to current phase of menstrual cycle, current use of contraceptives, and current neurological/psychiatric history were conducted aiming to identify confounders for the regression analysis.

ANOVA was conducted to test for significant differences in EF measures between three groups: No diagnosis, PMS, and PMDD. Confounders were not controlled in this analysis to procure ecological validity, since in clinical practice female patients may be at any phase of their menstrual cycle and likely taking oral contraceptives.

Lastly, linear regression was performed to test for interactions between PMS/PMDD symptoms and EF. Predictors considered for the model were moderately potent significant values from the bivariate correlation analysis ($r \geq .30$). Variance inflation factors (VIF) were estimated to test for multicollinearity between variables of the model, tolerating VIF below three.

Statistical significance was set a $p < .05$. All the analyses were performed using JASP version 0.11.1 (JASP Team, 2019).

Ethical considerations

All the procedures performed in this study were in accordance with the current Declaration of Helsinki.

RESULTS

As depicted in Figure 1, from a total of 180 approached individuals (164 from chain-referral and 16 from case sampling), only 157 accepted to participate and were analyzed; only four participants were enrolled from the case sampling procedure. From the total sample, age ranged from 18 to 33 years old. Almost all the participants reported having more than 12 years of education, only 29 were currently taking contraceptives, four and 29 reported history of neurological and psychiatric diagnosis, respectively, and 58 reported being currently at luteal phase of their menstrual cycle. Table 1 displays descriptive analysis by diagnostic groups. The *t*-tests showed no difference in self-reported nor performance-based EF relative to being currently in luteal phase, being currently using contraceptives, or having a history of neurological/psychiatric diagnosis, so these variables were discarded as confounders in the regression analysis.

Main significant ($p < .001$) correlations were found between PSST total score and results BRIEF-A-Luteal phase, and BRIEF-A-Follicular phases, with the former showing almost double the magnitude of correlation.

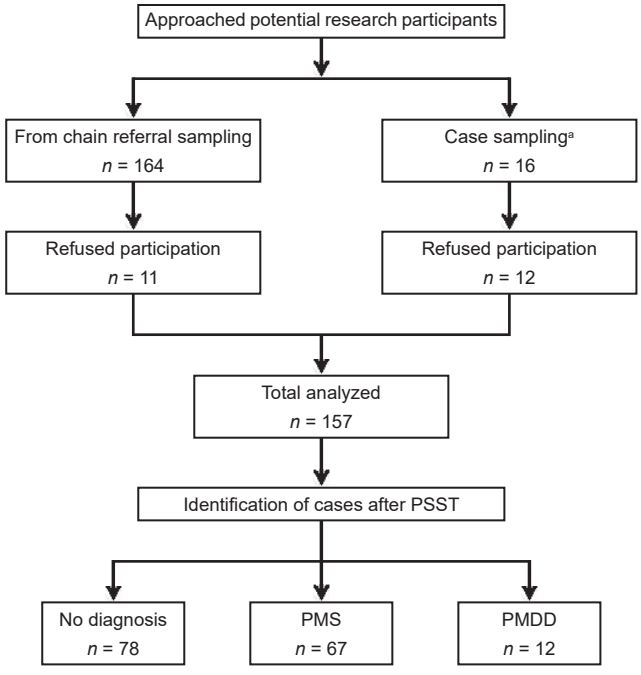

Figure 1. Flow of participant's recruitment.
Notes: [a]Women previously identified with possible premenstrual dysphoric disorder by a gynecologist in a private clinic.

Table 1
Characteristics of participants and comparisons between diagnostic groups

	No dx (n = 78)	*PMS (n = 67)*	*PMDD (n = 12)*	
	x̄(SD) or Freq.(%)	*x̄(SD) or Freq.(%)*	*x̄(SD) or Freq.(%)*	*Statistical differences*
Demographics				
Age	21.86 (3.05)	21.55 (2.32)	22.08 (2.43)	
Education				$\chi^2(2) = 1.02$, $p = .60$
≤ 12 years	1 (1.28)	0 (.0)	0	
> 12 years	77 (98.72)	67 (100.0)	12 (100.0)	
Currently in luteal phase	29 (37.18)	23 (34.33)	6 (50.00)	$\chi^2(2) = 1.08$, $p = .58$
Current use of contraceptive	13 (16.67)	15 (22.39)	1 (8.33)	$\chi^2(2) = 1.67$, $p = .43$
Neurological history	2 (2.56)	1 (1.49)	1 (8.33)	$\chi^2(2) = 1.92$, $p = .38$
Psychiatric history	13 (16.67)	15 (22.39)	1 (8.33)	$\chi^2(2) = 1.67$, $p = .43$
PSST Total				
Total score	15.86 (8.51)	20.13 (7.10)	40.67 (2.56)	$F(2,154) = 79.11$, $p < .001$
Daily-life impairment[a]	2.56 (1.98)	6.46 (2.29)	10.83 (2.37)	$F(2,154) = 109.76$, $p < .001$
BRIEF-A-Follicular phase				
Total score	7.12 (5.04)	10.25 (5.40)	10.08 (4.01)	$F(2,154) = 7.22$, $p = .001$
F1-Emotional regulation	2.47 (2.04)	3.19 (2.02)	3.50 (1.83)	$F(2,154) = 2.94$, $p = .05$
F2-Metacognition	3.08 (3.16)	4.63 (3.23)	4.00 (2.04)	$F(2,154) = 4.45$, $p = .01$
F3-Behavioral regulation	1.56 (1.54)	2.43 (1.64)	2.58 (1.38)	$F(2,154) = 6.32$, $p = .002$
BRIEF-A-Luteal phase				
Total score	8.50 (5.59)	14.09 (5.97)	19.25 (4.20)	$F(2,154) = 28.96$, $p < .001$
F1-Emotional regulation	3.67 (2.32)	5.43 (1.89)	7.83 (1.52)	$F(2,154) = 26.69$, $p < .001$
F2-Metacognition	3.21 (3.13)	5.94 (3.67)	7.33 (2.77)	$F(2,154) = 15.88$, $p < .001$
F3-Behavioral regulation	1.60 (1.48)	2.71 (1.79)	4.08 (1.31)	$F(2,154) = 16.80$, $p < .001$
Performed-based EF				
Stroop A - Errors	2.78 (3.25)	2.54 (2.63)	2.17 (2.12)	$F(2,154) = .29$, $p = .74$
Stroop B - Errors	2.37 (3.28)	2.81 (3.85)	3.25 (5.05)	$F(2,154) = .43$, $p = .64$
Stroop A - Time	75.76 (19.87)	75.96 (17.02)	78.55 (10.32)	$F(2,154) = .12$, $p = .88$
Stroop B - Time	64.59 (13.89)	66.73 (13.75)	70.99 (17.03)	$F(2,154) = 1.23$, $p = .29$
TMT A - Time	32.90 (11.19)	35.25 (13.41)	34.28 (10.67)	$F(2,154) = .67$, $p = .50$
TMT B - Time	59.70 (19.48)	63.58 (21.08)	67.87 (16.81)	$F(2,154) = 1.24$, $p = .29$
TMT A - Errors	.46 (.77)	.40 (.63)	.08 (.29)	$F(2,154) = 1.58$, $p = .20$
TMT B - Errors	1.24 (2.72)	1.40 (2.71)	.50 (.90)	$F(2,154) = .60$, $p = .54$
Number-Letter	18.91 (2.43)	18.21 (2.56)	17.00 (1.76)	$F(2,154) = 3.81$, $p = .02$

Notes: [a] Sum score of functional impairment in daily-life activities (items A-E of the PSST).

Abbreviations: BRIEF-A = Behavioral Rating Inventory of Executive Function-Adults; dx = diagnosis; EF = executive functions; TMT = Trail Making Test; PMS = premenstrual syndrome; PMDD = premenstrual dysphoric disorder; PSST = Premenstrual Symptoms Screening Tool.

Regarding associations of the PSST total with performance-based tests, significant ones were only found for TMT A-Errors and TMT B-Time. Lastly, only TMT A-Time and TMT A-Errors correlated mildly with the total score of BRIEF-A-Follicular and Emotional Regulation-Luteal respectively (Table 2).

Due to the low correlation values of the performance-based tests with PMS/PMDD symptoms, only the total scores of PSST and BRIEF-A-Luteal were considered as predictors in the linear regression model (Table 3). Explained variance of the model was 74%, but only the total score of the PSST probed to be a significant independent predictor of PMS/PMDD-associated impairment of daily-life functionality, and no interactive effect was found between PSST and BRIEF-A-Luteal. VIFs probed greater than three for all predictors, indicating high multicollinearity between variables of the model.

DISCUSSION AND CONCLUSION

The main goal of our study was to test the utility of self-reporting EF versus performance-based measures for the understanding of PMS/PMDD. We found that the results from a short version of the BRIEF-A strongly correlated with severity of PMS/PMDD as measured with the PSST. Furthermore, since we inquired the female participants to distinguish between their EF during luteal phase versus follicular

Table 2
Pearson's product-moment correlations between PMS/PMDD symptoms and EF

		BRIEF-A-Luteal phase				*BRIEF-A-Follicular phases*			
	PSST	*Total*	*Emotional regulation*	*Metacognition*	*Behavioral regulation*	*Total*	*Emotional regulation*	*Metacognition*	*Behavioral regulation*
PSST	--	.78 (.71, .83)	.73 (.65, .80)	.62 (.51, .70)	.62 (.51, .70)	.49 (.36, .60)	.42 (.21, .49)	.36 (.22, .50)	.49 (.22, .50)
Stroop A-Time	--	--	--	-.15 (-.003, -.30)	--	--	--	--	--
TMT A-Errors	-.15 (-.002, -.30)	--	-.17 (-.01, -.32)	--	--	--	--	--	--
TMT A-Time	--	--	--	--	--	--	.15 (.00, .30)	--	--
TMT B-Time	.16 (.00, .31)	--	--	--	--	--	--	--	--

Notes: Displayed values correspond to *r* (95% confidence interval). Only correlations at $p < .05$ are shown; bolds indicate $p < .001$
Abbreviations: BRIEF-A = Behavioral Rating Inventory of Executive Function-Adults; EF = executive functions; TMT = Trail Making Test; PMS = premenstrual syndrome; PMDD = premenstrual dysphoric disorder; PSST = Premenstrual Symptoms Screening Tool.

phases, we found that these associations were almost double the magnitude for the former. In addition, the direct link between these variables also expressed itself when comparing ordinal groups of participants with PMS and PMDD versus participants with mild to no symptomatology.

This finding is in direct agreement with the study by Yen et al. (2011) showing associations between self-reported hostility, impulsivity, and behavioral inhibition measures and PMDD (previously screened with the PSST). That study carefully recruited women during luteal and follicular phases, and compared them to a control group. Our study extends those results by suggesting that subjective retrospection of EF deficits also renders similar results and, moreover, that these deficits manifest themselves according to an empirical factorial structure of EF: Emotional Regulation, Metacognition, and Behavioral Regulation (Roth et al., 2013), meaning that women with PMS/PMDD express difficulties involving intrinsic initiation of behavior, working memory, planning, organization, self-monitoring of cognition and behavior, mental shifting, emotional control and inhibition of prepotent response. Furthermore, these difficulties seem to continue in a milder degree during follicular phases. As we stated at the beginning of this paper, these cognitive deficits, and their associated deficits in top-down regulation of the frontal lobes over the limbic system, may be at the core of some of the characteristic features of PMS/PMDD. As examples: (a) rumination could be a display of cognitive inflexibility and deficits in updating of working memory, by which the individual is not able to switch from a set of negative thoughts that overdrive its executive capacities, making her less efficient to process other sets of thoughts; (b) impulsivity could be a manifestation of an intrinsic difficulty to inhibit preponderant emotional responses which finally override the motor output of behavior in the form of aggression or risky behavior (e.g., sexual or financial); and (c) deficits in attentional control that leads to excessive awareness of environmental threats could partially explain the abnormal anxiety in these disorders.

Table 3
Linear regression model of interactive effects between PMS/PMDD symptoms and EF as predictors of daily-life functional impairment

	Unstandardized estimates	*Standard error*	*p*	*95% CI*	*Variance inflation factor*
Intercept	-53	.49	.28	[-1.5, .45]	--
PSST	.24	.02	<.001	[.19, .30]	4.82
BRIEF-A-Luteal	-.09	.05	.08	[-.20, -.01]	7.48
PSST × BRIEF-A-Luteal	.003	.002	.13	[-8.41e-4, .006]	13.38

Notes: Outcome variable: Sum score of functional impairment in daily-life activities (items A-E of the PSST).
Model summary: $R^2 = .74$, $p < .001$; $F(3,153) = 149.64$, $p < .001$.
Abbreviations: BRIEF-A = Behavioral Rating Inventory of Executive Function-Adults; EF = executive functions; PMS = premenstrual syndrome; PMDD = premenstrual dysphoric disorder; PSST = Premenstrual Symptoms Screening Tool.

Assuming that the self-report measures used in our study are equally valid, the magnitude of the bivariate associations, the lack of interactive effects, and the high values of multicollinearity observed in our linear regression model, suggest that EF deficits and PMS/PMDD symptoms, particularly during luteal phase, may be as closely linked as to allow for the consideration of PMS and PMDD as mild and moderate forms of dysexecutive syndrome. This suggestion may be supported by neuroscientific findings relating prefrontal lobe dysfunction and consequent diminished top-down control of the limbic system in females with PMDD (Protopopescu et al., 2008), as well as for other depressive disorders (Snyder et al., 2015).

Limitations concerning the use of self-reports are a constant danger in psychological assessment, and these first findings of our study should be taken cautiously because of possible biases such as desirability, selective retrospective recall, and influences between measures. We believe some tempering of these biases may have been granted by the high education of our participants and the fact that we encouraged them to carefully reflect on the statements of the self-reports prior to provide their answer (Mackenzie & Podsakoff, 2012). Further studies should also ensure the use of an independent measure of PMS/PMSS-associated clinical functionality; since we only used the last items of the PSST, it is hard to conclude that no interaction might be found between variables when multicollinearity is methodologically controlled.

On a contrary note, only very weak associations between self-reported symptoms of PMS/PMDD and performance-based measures of mental shifting and working memory were found. Though we observed no effect of menstrual phase at the moment of the evaluation, with considerable likelihood this finding would have been different having controlled for this variable with a methodological approach, forming paired groups of luteal versus follicular phases. Also, it is quite possible that the three performance tests we employed were limited in their content validity with regards to the factor model proposed by Friedman and Miyake (2017), which indeed requires the use of more than just one measure of EF per factor (this was a limitation we had to assume since we gave priority to gather a larger sample by sacrificing a more comprehensive assessment).

If we deem this finding to be informative, we may consider that EF deficits associated to PMS/PMDD are only minimally registered by common performance tests. This has been described by Souza et al., (2012) who reviewed and reported no changes in performance on common EF tasks relative to diagnoses of PMS or PMDD, though the reported findings in this review are rather inconsistent since other cognitive functions such as working memory and attention are reported to be impaired but not considered under the umbrella term of EF. A more recent original study (Slyepchenko et al., 2017) found subtle deficits in working memory and attention in women with PMS/PMSS during follicular phases, which contradicts our first assumption.

However, findings deficits in tests of neuropsychological performance is only one step in the assessment process; information concerning the particular effect of EF deficits on clinical outcomes related to the neurological or psychiatric pathology should always be procured as to make the neuropsychological assessment meaningful in a real-life context. We tried to provide this information by analyzing interactive effects of EF but, as stated above, failed to find them due to multicollinearity of self-reported EF, and the weak correlations between performance-based measures and PMS/PMDD symptoms.

Overall, we believe that the integration of self-reports to the assessment of EF in women with PMS or PMDD should receive more attention from researchers, particularly to better understand these disorders from a neuropsychological perspective: as the behavioral expression of a neurocognitive anomaly, and not only as the cause of mildly impaired performance in tasks with restricted ecological validity.

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Conflict of interest

The authors declare they have no conflicts of interest.

Contributions

All authors conceptualized and designed the study and participated in the writing of the manuscript. FM-M, MJP-A, MFV-V, CPB-S recruited the participants, collected the data, and conducted descriptive analysis. AT-F performed inferential analyses, provided methodological guidance, and reviewed the final manuscript.

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