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Relationship between depressive symptomatology and cognitive performance in older people

Relación entre la sintomatología depresiva y el desempeño cognitivo en adultos mayores

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Abstract
Objective: To analyze the relationship of depressive symptoms with differentiated components of cognitive function in older adults using the Neuronorma.Co protocol. Methodology: We analyzed the cognitive performance of 144 adults, 58.3% women, with an average age of 68.1 ± 11.2 years. A factor analysis of main components was performed to identify independent factors of cognitive function. Multiple linear regression analysis was used to estimate the type and strength of association between depressive symptoms and neurocognitive performance components. Results: Seven differentiated components of cognitive performance were identified. In the multivariate analysis, interference control and language were affected by the total score on the Yesavage Geriatric Depression Scale. Conclusions: The presence and intensity of depressive symptoms is associated with a lower performance in tasks dependent on executive control.
Resumen
Objetivo: Analizar la relación de los síntomas depresivos con componentes diferenciados de la función cognitiva de adultos mayores usando el protocolo Neuronorma.Co. Metodología: Se analizó el rendimiento cognitivo de 144 adultos, $58,3\%$ mujeres, con una edad media de $68,1 \pm 11,2$ años. Se realizó un análisis factorial de componentes principales, para identificar factores independientes de la función cognitiva. Se usó el análisis de regresión lineal múltiple para estimar el tipo y la fuerza de asociación entre síntomas depresivos y los componentes del desempeño neurocognitivo. Resultados: Se identificaron siete componentes diferenciados del rendimiento cognitivo. En el análisis multivariado el control de la interferencia y el lenguaje resultaron afectados por la puntuación total en la Escala de Depresión Geriátrica de Yesavage.

Keywords
cognitive functioning components; geriatric depression; neuropsychological evaluation.
Palabras Clave
componentes del funcionamiento cognitivo, depresión geriátrica, evaluación neuropsicológica.

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1. Introduction

Exploring the relationship between depression and cognitive performance is relevant when dealing with factors associated with normal and pathological aging. It has been established that, in older population, depression is a risk factor for cognitive deterioration (Roca Socarrás & Henriette, 2012; Steenland et al., 2012). Furthermore, for those who already have mild cognitive impairment (MCI), depressive disorder is a worsening factor (Gabryelewicz et al., 2007). The causal relationship between depression and neurodegenerative diseases seems to be clear. A meta-analysis of longitudinal studies established that depression nearly doubles the risk of cognitive deterioration (Gao et al., 2013). It is also known that the more depressive episodes, the greater the

risk of dementia (Da Silva, Goncalves-Pereira, Xavier, & Mukaetova-Ladinska, 2013). Another evidence favoring this hypothesis is the results of large databases of records of psychiatric cases in Scandinavian countries, which shows how the use of antidepressants leads to a lower incidence of dementia (Kessing, Sondergard, Forman, & Andersen, 2009).

A close relationship has also been found between the appearance of depressive symptoms, the reduction of cognitive capacity, and the presence of chronic diseases, like cerebrovascular diseases, hypertension, diabetes, cancer, and chronic obstructive pulmonary disease—conditions that are highly prevalent in older people (Alvarán, Gómez, Aguirre, & Ortiz, 2008; Kirkman et al., 2012; López Torres et al., 2014; Roca Socarrás & Henriette, 2012; Smith & Blumenthal, 2011; Stanley, 2014).

Depressive symptoms are the most common neuropsychiatric symptoms in MCI, and can be considered as a transition state between normal cognition and dementia. Several studies have established a significant relationship between the severity of depressive symptoms and the deterioration of cognitive functions (Spira, Rebok, Stone, Kramer, & Yaffe, 2012). Some meta-analyses have also determined that depressive patients show alterations in executive functions (EFs) and the working memory, which has collateral effects on other cognitive domains (Bora, Harrison, Yücel, & Pantelis, 2013; Rock, Roiser, Riedel, & Blackwell, 2014; Snyder, 2014).

Other studies have explored the effect of depressive symptoms as risk factors (Dotson, Beydoun, & Zonderman, 2010; Ownby, Crocco, Acevedo, John, & Loewenstein, 2006) and even as prodromes of cognitive impairment (Dotson et al., 2010), and have proposed that the reduction of depressive symptoms decreases the risk of deterioration progression (Steenland et al., 2012).

Furthermore, a longitudinal study with 562 people aged 65–85 years examined the relationship of depressive symptoms with the diagnosis of cognitive impairment and dementia, to determine whether these symptoms predict continuous cognitive deterioration. After a three-year follow-up, researchers did not obtained results that supported this idea (Neubauer, Wahl, & Bickel, 2013). Probably, the use of nonspecific tools to detect cognitive impairment in early stages, like the Mini-Mental State Examination used in this study, explains these negative results.

It can be assumed that there is a dimensional relationship between the appearance of depressive symptoms and cognitive deterioration. Empirical evidence suggests that depression is a risk factor and a prodrome of MCI and dementia (Kessing, 2012). Moreover, it has been determined that an appropriate treatment of depression can mitigate the burden of dementia (Steenland et al., 2012).

In Colombia, studies evidence the need to characterize the effects of depressive symptoms on cognitive performance, taking into account moderating factors such as habits and medical history. This relationship should also be explored using measurements adapted and validated for our population, since it is usual to use scales designed for other populations. Thus, the purpose of this study was to analyze the relationship between depressive symptoms and differentiated components of the cognitive function in older people, using a neuropsychological assessment battery adapted and validated in the Colombian population.

2. Method

2.1 Participants

The study included 144 adults over the age of 49, selected through non-probabilistic sampling. Subjects who fulfilled the requirements to participate were identified using the snowball technique; and they, in turn, helped locate other participants with similar characteristics.

Most of the subjects were invited to the study by the members of the NEUROPSIS undergraduate research group, from the School of Psychology of Universidad de San Buenaventura (Medellín), who explained to their relatives and acquaintances the objective of the study and put them in contact with the researchers for evaluation. This mechanism resulted in a sample that included employees of the university, relatives of the research group members, and older people who were part of senior clubs, attended day care centers, or resided in assisted living facilities.

The study excluded those people with pathology of the central nervous system that could affect cognition, other than a MCI caused by a possible process of dementia; unstable or clinically significant cardiovascular disease within 6 months prior to the evaluation; or history of alcohol or drug abuse within 24 months prior to the evaluation.

2.2 Measures

The Subjective Memory Complaints scale (Hernández, Montañés, Gámez, Cano, & Núñez, 2007) was used to select and classify the participants, and the Geriatric Depression Scale (Yesavage et al., 1982) was applied to evaluate current depression. In addition, all participants were asked for sociodemographic information, personal health history, habits, and use of medicines.

The evaluation of cognitive performance was conducted using Neuronorma.Co—a neuropsychological assessment battery adapted and validated for Colombia by Patricia Montañés' team at Universidad Nacional de Colombia (Montañés, 2016). In Colombia, normative data were calculated for ten age groups and according to the effect of sociodemographic variables such as schooling and sex, given the broad spectrum of the population that ranges from functional illiterate people to people with

postgraduate studies. The use of the normative data obtained from such a diverse sample favors the reliability of the diagnoses in Colombia, as well as the unification of criteria for interpreting tests. This battery has exhibited good psychometric properties for the evaluation of this population and has been used in other studies in the country (Duarte, Espitia, & Montañés, 2016).

The Neuronorma.Co battery tasks used in this research to evaluate the cognitive functions were: 1) Digit Span Task (backward and forward) from the WAIS-III; 2) Trail Making Test (parts A and B; 3) Symbol Digit Modalities Test; 4) Visuospatial Span Task (forward and backward Corsi Blocks Test) (Peña Casanova, Quiñones Úbeda, et al., 2009c); Boston Naming Test; 6) Token Test (Peña Casanova, Quiñones Úbeda, et al., 2009a); 7) Rey–Osterrieth Complex Figure (Copy and Recall) (Peña Casanova, Gramunt-Fombuena, et al., 2009); 8) Learning and Memory Task with Controlled Encoding (Hernández et al., 2007); 9) Wisconsin Card Sorting Test (Grant & Berg, 1948); 10) Tower of London Test; 11) Stroop Color and Word Test (Peña Casanova, Quiñones Úbeda, et al., 2009b); 12) Verbal Fluency Task (Isaacs & Kennie, 1973); and 13) Phonological Fluency Task (Borkowski, Benton, & Spreen, 1967).

2.3 Procedure

This research was approved by the Bioethics Institutional Committee of Universidad de San Buenaventura, Medellín. Once the evaluator explained the details of the study, each participant signed a written informed consent. Subsequently, the evaluation was conducted in two sessions: the clinical scales and the attention and memory tasks were applied in the first session, while the second session consisted of tasks related to visuospatial abilities, language, and EFs from the Neuronorma.Co battery.

The staff that conducted the evaluations and participated in the edition and storage of the data was trained for applying the protocol. Special emphasis was placed on the study of handbooks, videos, and materials required in each neuropsychological or psychological test. A database was designed in Microsoft Access 2016 for storing the data obtained. Direct scores were included along with scalar scores categorized by age and schooling in the Colombian sample (Montañés, 2016), the latter scores being preferred in the analyses. Once collected, the data were exported to the SPSS 23.0 software for statistical treatment.

2.4 Data analysis

Performance in the Neuronorma.Co battery, in the clinical scales, and in the screening tools is expressed in average scores and standard deviations. As for the categorical variables, their frequencies are described in percentage terms.

To identify factors that do not depend on cognitive functioning, an exploratory factor analysis (EFA) of the scalar scores obtained in the tasks that make up the Neuronorma.Co battery was carried out through a principal component analysis (PCA) with orthogonal rotation (varimax). To determine the number of factors to be kept, the following criteria were considered: eigenvalues should be greater than 1 and derived from each component, the factors kept should explain at least 60% of the variance and, finally, each factor should have at least three variables with significant factor weights. A standard score for each subject was generated by calculating the average scalar performance in the set of neuropsychological tasks of each component.

Spearman's correlation coefficients were examined to identify the correlations between the total score in the Yesavage Geriatric Depression Scale and the standard scores in each component obtained from the Neuronorma.Co neuropsychological battery. The Mann–Whitney U test was used to analyze the relationship of cognitive performance with dichotomous categorical variables.

Finally, the type and strength of the relationship between depressive symptoms and cognitive performance were estimated using multiple linear regression models. Every equation included the parameters of interest, that is the score obtained in each cognitive component as a dependent variable, and the independent variables, such as the total score in the Yesavage Depression Scale, the years of schooling, and each of the covariates relevant to the bivariate analysis. The Backward method was used to select the variables in the final model. A significance level of $p < 0.05$ was assumed for all contrasts.

3. Results

Table 1 summarizes the sociodemographic and clinical characteristics of the participants.

Table 2 shows the mean scores and standard deviations that reflect the performance in the Neuronorma.Co battery.

3.1 Factor analysis

The PCA with varimax rotation included 29 standardized measures collected from 14 neuropsychological tests. The overall measure of sampling adequacy was appropriate (KMO=0.807). The Bartlett's test of sphericity $\chi^2_{(406)} = 2,085.94$ $p < 0.001$ indicates that the correlation between the variables was strong enough for the PCA.

Seven factors with eigenvalues greater than 1 were extracted; their combination explained 68.36% of the variance (Table 3). The first factor groups tasks associated with *memory* functioning; the second factor displays the performance in tasks typically related to interference control or *inhibitory control*; the third component consists of variables that account for the performance in *categorization* and *flexibility* processes; the fourth factor groups

Table 1

Sociodemographic and clinical characteristics of the sample.

	N	**%**
Sex		
Man	60	41.7
Woman	84	58.3
Education		
Illiterate	4	2.8
Primary education (unfinished)	32	22.2
Primary education	7	4.9
Secondary education (unfinished)	24	16.7
Secondary education	19	13.2
Associate degree	27	18.8
Higher education	31	21.5
Bilingualism		
Yes	21	14.6
Marital status		
Married	45	31.3
Separated/Divorced	32	22.2
Single	40	27.8
Widowed	27	18.8
Habits		
Coffee consumption	106	74.1
Alcohol consumption	16	11.3
Tobacco consumption	18	13.7
Personal medical history		
Hypertension	53	37.1
Dyslipidemia	53	37.1
Diabetes	14	9.8
Thyroid disease	25	17.5
Medication		
Antidepressants	16	11.1
Anxiolytics	5	3.5
Neuroleptics	3	2.1
Anti-dementia drugs	10	6.9
Antiplatelets	9	6.3
Antiarrhythmics	2	1.4

	$M \pm SD$
Age	68.11 ± 11.2
Years of schooling	10.4 ± 5.5
Total memory complaints	12.9 ± 8.4
Total Yesavage scale	2.35 ± 2.7

Table 2

Descriptive statistics of the scalar scores obtained in the neuropsychological battery applied to 144 adults.

	M	***SD***	***Minimum***	***Maximum***
Forward Verbal Span	11.01	2.49	4	18
Backward Verbal Span	10.99	2.89	6	18
Forward Visuospatial Span©	10.73	2.95	5	18
Backward Visuospatial Span©	10.83	3.31	5	18
Trail Making Test A	9.1	2.89	2	16
Trail Making Test B	9.1	2.87	2	16
SDMTc©	9.66	2.94	3	18
Boston Naming Test©	8.53	3.41	2	18
Token Test	8.73	3.5	2	18
ROCF (Copy)	9.15	4.03	2	18
ROCF (Recall)	10.61	2.15	6	16
FCSRT (Free recall – Trial 1)	8.64	3.58	2	18
FCSRT (Total free recall)	7.67	3.75	2	18
FCSRT (Total recall)	7.32	3.9	2	18
FCSRT (Delayed free recall)	7.23	3.44	2	18
FCSRT (Delayed total recall)	7.75	5.28	2	18
ROCF (Immediate recall – 3 minutes)	7.93	3.44	2	17
Semantic verbal fluency	8.87	3.34	2	18
Phonemic verbal fluency (p)	9.58	2.96	2	18
Stroop Test© (Word)	8.31	3.14	2	15
Stroop Test© (Color)	9.01	3.45	2	18
Stroop Test© (Word-Color)	9.01	3.34	2	17
Stroop Test© (Interference)	8.46	3.26	1.5	16.41
TOL-DX© (Total correct)	10.08	3.03	2	17
TOL-DX© (Total moves)	9.14	3.28	2	18
TOL-DX© (Initiation time)	9.48	3.98	2	18
TOL-DX© (Execution time)	8.83	3.72	2	18
TOL-DX© (Total time)	9.15	3.81	2	18
WCST-M (Categories completed)	9.94	3	3	18
WCST-M (Perseverative errors)	9.31	3.43	3	19
WCST-M (Correct answers)	9.13	3.32	2	18
WCST-M (Attentional failures)	14.51	4.73	3	18

Note: SDMTC© = Symbol Digit Modalities Test; ROCF = Rey–Osterrieth Complex Figure; FCSRT = Free and Cued Selective Reminding Test - Immediate Recall; TOL-DX© = Tower of London; WCST-M = Wisconsin Card Sorting Test (Modified).

Table 3

Summary of the results of the factor analysis for the scalar scores in neuropsychological tests ($n = 111$).

	Rotated factor loadings						
	F1	F2	F3	F4	F5	F6	F7
FCSRT (Total free recall)	0.902						
FCSRT (Total recall)	0.877						
FCSRT (Delayed free recall)	0.845						
FCSRT (Free recall – Trial 1)	0.778						
FCSRT (Delayed total recall)	0.774						
ROCF (Immediate recall – 3 minutes)	0.551						
Stroop Test© (Interference)		0.815					
Stroop Test© (Word-Color)		0.783					
Stroop Test© (Color)		0.736					
Stroop Test© (Word)		0.64					
SDMTc©		0.515					
Trail Making Test B		0.41					
WCST-M (Correct answers)			0.903				
WCST-M (Categories completed)			0.832				
WCST-M (Perseverative errors)			0.762				
Phonemic verbal fluency (p)				0.651			
Backward Verbal Span				0.625			
Forward Verbal Span				0.62			
Token Test				0.605			
Boston Naming Test©				0.477			
Backward Visuospatial Span©					0.753		
Forward Visuospatial Span©					0.586		
ROCF (Copy)					0.416		
ROCF (Recall)						0.779	
Trail Making Test A						0.666	
Semantic verbal fluency						0.617	
TOL-DX© (Total time)							0.864
TOL-DX© (Execution time)							0.85
TOL-DX© (Initiation time)							0.528
Eigenvalues	9.25	3.38	1.9	1.43	1.42	1.23	1.2
% of variance	14.97	12.23	9.09	8.89	7.93	7.68	7.54
Cronbach's α	0.9	0.89	0.85	0.81	0.7	0.65	0.81
Standard score M±SD	7.7 ± 3.2	8.8 ± 2.6	9.4 ± 2.8	9.7 ± 2.3	10.2 ± 2.7	9.5 ± 2.2	9.1 ± 3.2

Note: The table only shows the significant factor loadings (equal to or greater than 0.375). The Cronbach's coefficient α for each factor has been calculated based on the items with a factor loading > 0.375.

tasks that show the performance in *language*; the fifth factor describes the performance in *visuospatial planning*; the sixth factor accounts for the *processing speed*; and, finally, the seventh component contains the processes required for *planning* (Tirapu-Ustárroz, Cordero-Andrés, Luna-Lario, & Hernáez-Goñi, 2017).

A standard score corresponding to the average scalar score obtained from the variables grouped in each factor was generated for each subject (Table 3). Since these values reflect accurately the structure of the factor, they were used in the subsequent analysis.

3.2 Correlations between depressive symptoms and scores in cognitive factors

A correlation analysis was performed to observe the influence of age and schooling, besides the total score, on the Yesavage Geriatric Depression Scale, through a Spearman's rank correlation coefficient (ρ). The results are shown in Table 4.

The relationships between the cognitive factors and the variables related to habits and medical history were examined using the Mann–Whitney U test. It was found that memory tasks are affected by tobacco consumption ($U = 615$; $p < 0.01$), drug abuse ($U = 1.5$; $p < 0.05$), use of antiarrhythmic drugs ($U = 26.5$; $p < 0.05$), and use of anti-dementia drugs ($U = 179.5$; $p < 0.001$).

The performance in visuospatial tasks is also different in men and women ($U = 1975$; $p < 0.05$), and varies in tobacco users ($U = 619$; $p < 0.01$) and individuals with history of hypertension ($U = 1789$; $p < 0.05$). These abilities are also affected by the use of antiplatelets ($U = 278$; $p < 0.01$), anxiolytics ($U = 108$; $p < 0.01$), and neuroleptics ($U = 31$; $p < 0.05$). Tobacco consumption also intervenes in the processing speed ($U = 675$; $p < 0.05$). Finally, sex ($U = 1377$; $p < 0.01$) and use of anti-dementia drugs ($U = 359$; $p < 0.05$) have an impact on planning.

3.3 Multiple regression analysis

In the multiple regression analysis, each cognitive component was examined separately.

For the *memory* component, the multiple regression coefficient of the model (R) was 0.511; the adjusted R^2 (coefficient of determination) was 0.237; the level of significance of the F test (10.843) in the analysis of variance was $p < 0.001$; the β values, that indicate the intensity of the effect of each variable of the final model, were $\beta = 0.285$, $p = 0.001$ for years of schooling and $\beta = -0.298$, $p < 0.001$ for the use of acetylcholinesterase inhibitors. Depressive symptoms do not affect the variance of the scores obtained in this ability ($\beta = -0.003$, $p = 0.971$).

In *inhibitory control*, the coefficient R was 0.542 and the adjusted R^2 was 0.283. The significance value of F (26.667) was $p < 0.001$. The variables with significant effect on this factor were the total score on the Yesavage Depression Scale ($\beta = -0.187$, $p = 0.018$) and years of schooling ($\beta = 0.451$, $p < 0.001$).

Regarding the performance in *categorization and flexibility*, only the years of schooling were significant ($\beta = 0.291$, $p < 0.001$). Although the standardized coefficient of the total score in the Yesavage Depression Scale was negative, it did not reach significant levels ($\beta = -0.022$, $p = 0.802$). The general parameters of the model adjusted well: $R = 0.291$ and adjusted $R^2 = 0.078$. The level of significance of the F test (12.123) in the analysis of variance was $p = 0.001$.

Language was affected by the scores in the Yesavage Depression Scale ($\beta = -0.179$, $p = 0.029$), the years of schooling ($\beta = 0.384$, $p < 0.001$), and the use of antiarrhythmic drugs ($\beta = 0.155$, $p = 0.045$). In this model, the value of R was 0.518, the adjusted R^2 was 0.251, and the significance level of the F test (15.539) was $p < 0.001$.

The model for the *visuospatial planning* component showed good fit indices: $R = 0.546$; corrected $R^2 = 0.269$; F statistic=10.443 ($p < 0.001$). The β values indicate that the years of schooling ($\beta = 0.297$, $p < 0.001$) improve the performance of this function, while male sex ($\beta = -0.188$, $p = 0.018$) seems to be associated with a worse performance. It is striking that the use of anxiolytics ($\beta = -0.180$, $p = 0.023$) and neuroleptics ($\beta = -0.181$, $p = 0.021$) is associated with better performance in this ability. Depressive symptoms were not significant in the final model ($\beta = -0.151$, $p = 0.075$).

The performance in processing speed was only explained by the years of schooling ($\beta = 0.407$, $p = 0.023$) ($R = 0.407$; corrected $R^2 = 0.159$; $F = 25.64$ $p < 0.001$).

Lastly, as for the performance in planning, the values of β indicate that the number of years of schooling ($\beta = 0.285$, $p = 0.001$) and the sex ($\beta = 0.176$, $p = 0.041$) are the variables that explain the percentage of variance of this ability ($R = 0.357$; corrected $R^2 = 0.114$; $F = 9.011$ $p < 0.001$).

4. Discussion

The purpose of this research was to study the relationship between depressive symptomatology and cognitive performance in older people, taking into account sociodemographic characteristics, habits, and medical history. The results obtained show that people with these symptoms have a reduced cognitive performance in interference control and language (Spira et al., 2012). This finding is consistent with other studies that have established that depressive patients exhibit alterations in EFs and working memory, hence affecting other cognitive domains (Bora et al., 2013; Rock et al., 2014; Snyder, 2014).

To explore this idea, it was necessary to analyze the magnitude, significance, and direction of the Spearman's correlation coefficient between the total score in the depression scale and each of the scores in the seven factors, five of which were inversely associated with depressive

Table 4

Correlation between age, years of schooling, and total score in the Yesavage Geriatric Depression Scale and the seven neuropsychological factors in a sample of 144 older adults.

	Age	Years of schooling	Total Yesavage
Memory	−0.237**	0.312***	−0.209*
Inhibitory control	−0.213*	0.514***	−0.279**
Categorization and flexibility	−0.246**	0.293**	−0.1
Language	-0.093	0.459***	−0.231**
Visuospatial planning	−0.280**	0.407***	−0.225**
Processing speed	0.047	0.347***	-0.123
Planning	−0.289**	0.314***	−0.228*

Note: ρ = Spearman's rank correlation coefficient (ρ). $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

symptoms: memory, inhibitory control, language, visuospatial planning, and planning. These results coincide with other studies (Dechent, 2008; Goodale, 2007). However, in the multivariate analysis, memory, visuospatial abilities, and planning were not explained significantly by the variation in depressive symptoms.

Interference control and language kept the significant association under the statistical control of the covariates in the multivariate models. These two factors can be explained from the construct proposed by Stuss (1992), who defined EFs from a functional perspective as a set of complementary abilities that make it possible to set and maintain goals in the working memory, control their execution, and prevent possible distractions from interfering with their achievement. The author also proposes an executive functioning model based on the neuroanatomical location and interconnection of the areas related to EFs (Stuss, 1992).

The dorsolateral prefrontal cortex (DLPFC) is related to the most complex cognitive processes (Fuster, 2002). It is a multimodal association area that integrates information coming from the unimodal, heteromodal, and paralimbic association areas—connected to mood. EFs such as planning, abstraction, working memory, fluency, complex problem solving, cognitive flexibility, serialization and sequencing, and organization are attributed to this area (Alexander & Stuss, 2000). Our results can be explained in light of these anatomical and functional observations, given that interference control and language concentrate tasks that require the optimal performance of cognitive processes managed by the DLPFC that have been classified as particularly sensitive to the presence of depressive symptoms (Alexopoulos, Kiosses, Klimstra, Kalayam, & Bruce, 2002; Dechent, 2008; Goodale, 2007).

This study found an inverse linear relationship between the severity of the depressive symptoms and the visuospatial planning abilities. It has been established that the difficulties that people with depression exhibit in processes involving visuospatial planning and ability to perform cognitive activities that require manipulation of visual material could be explained by the alteration in the connection of the DLPFC neural activity (Alexander & Stuss, 2000), in addition to faults in the visual working memory updating and the spatial and functional activation that exists in visual and prefrontal areas (Le, Borghi, Kujawa, Klein, & Leung, 2017).

This suggests that depressive symptoms and cognitive performance are significantly related, due to the role of the common mechanism that includes alterations in visual and prefrontal processing during vision control and selection and retention of information. Therefore, the ability to improve the execution of the relevant task and inhibit nonrelevant information will be affected in the presence of depressive symptoms (Le et al., 2017).

The results of this study concerning the relationship between depressive symptoms and performance in interference control can be discussed in the light of the findings by Hartikainen, Ogawa, and Knight (2012), who conducted a study in which they found evidence in favor of the role of emotional modulation in the allocation of attention resources.

In our study, the tasks grouped in the *inhibitory control* factor are closely related to the ability to control the interference of irrelevant stimuli and the inhibition of responses in visual processes—something that is negatively impacted by the presence and intensity of depressive symptoms. It has been determined that the medial frontal cortex (MFC) has an influence on processes such as inhibition, detection and resolution of conflicts, regulation, and attentional effort. It also participates in the regulation of aggression and motivational states (Fuster, 2002). Therefore, it can be assumed that this area is involved in the relationship found in this research.

In this regard, a recent study analyzed the functional consequences of brain changes in depression at a perceptual level, through the observation of a basic visual process, specifically, the inhibitory process within the visual motion system called center-surround suppression (CSS). The authors found that the inhibitory perceptual process is altered in currently depressed individuals,

and that gamma-aminobutyric acid (GABA) depletion may be responsible for the difficulties in discriminating the direction of motion under specific conditions (Norton, McBain, Pizzagalli, Cronin-Golomb, & Chen, 2016). The above can explain our findings, considering that low scores in interference control are associated with a greater presence of depressive symptoms in our sample.

The results of this study also show that schooling is a relevant variable when analyzing the factors that affect cognitive performance in older people. However, it is worth mentioning that there is no consensus in the literature about the role of schooling in older adults with depressive symptoms.

On the one hand, some authors, based on the theory of cognitive reserve, state that schooling is one of the factors that contributes to the well-being of older adults and presume that there is no direct relationship between the severity of a neurological pathology and its effect on cognitive functioning. Thus, individuals with greater cognitive reserve will be able to face a more severe pathology without their cognitive performance being affected; contrary to individuals with a reduced reserve, who will have cognitive alterations in the presence of less severe pathologies (Stern et al., 2003). Therefore, schooling is a fundamental aspect in the individual variability of cognitive reserve (Stern, 2003).

Chen, Copeland, and Wei (1999) point out that low schooling levels and adverse socioeconomic conditions are risk factors for depressive disorders in older people. Similarly, a recent longitudinal study, which monitored 6,220 people from 2002 to 2015, found that belonging to a low socioeconomic stratum—also associated with low schooling levels—increases the risk of developing dementia by a factor of 1.68 (95% CI, 1.05 − 2.86) (Cadar et al., 2018).

In conclusion, our study shows that depression is related to a lower cognitive performance in older adults; specifically, the presence and intensity of depressive symptoms is associated with lower performance in tasks dependent on executive control.

The strengths of our study are related to the specificity and sensitivity of the instruments used for the neuropsychological assessment of the sample, since, as stated by Ismail, Malick, Smith, Schweizer, and Fischer (2014), when conducting research on the role of depression in cognitive performance, it is indispensable to use solid instruments to evaluate all cognitive domains.

Our study is not exempt from limitations. Its transversal design does not allow us to address causal relationship. This limitation raises the need for longitudinal studies with appropriate designs and sample sizes to allow researchers to explore this type of relationship. Another limitation is the implementation of a convenience sampling, which reduces the capacity to make generalizations about the whole older population. Finally, it is necessary to perform a more precise measurement of the diagnosis of depression and a better quantification of its severity and etiology.

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