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Cognitive scores as a potential diagnostic tool in schizophrenia: The use of raw and discrepancy scores

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Abstract

Objective: Cognitive scores could be a useful tool when discriminating between patients with schizophrenia (SZ) and non-psychiatric population. However, whether these scores can contribute to the accurate diagnosis of the disease is still unclear. Therefore, this study aimed to identify the best approach as to the inclusion of cognitive impairment as a potential clinical tool in the diagnosis of SZ.

Method: A total of 258 patients with SZ and 202 healthy controls (HC) were assessed by means of the Hopkins Verbal Learning Test-Revised (HVLT-R) and the Trail Making Test-A (TMT-A). In addition to raw scores, participants' discrepancy scores (DS) in these two cognitive measures were calculated using regression-based norms controlling for age, years of education and premorbid intelligence quotient. Receiver-operating characteristic analyses were performed for both scores in order to assess their diagnostic properties.

Results: The areas under the curve (AUC) of the HVLT-R total and delayed recall, and TMT-A raw scores were statistically significant and ranged from 0.67 to 0.87. Although significant, AUC of verbal memory DS were lower than those of raw scores (AUC = 0.84; AUC = 0.80). AUC of TMT-A DS was not significant.

Conclusions: Results suggest that cognitive scores are useful and accurate when discriminating and classifying patients with SZ and HC in the present sample. Raw scores were shown to be more accurate than DS in patients with SZ and to present good diagnostic properties especially regarding verbal memory measures. Obtained indices support the use of cognitive scores as diagnostic criterion in the diagnosis of SZ.

KEYWORDS
assessment, cognition, discrepancy scores, processing speed, schizophrenia, verbal memory

Cognitive impairment in schizophrenia (SZ) has been widely identified in many studies and across different cognitive domains (Heinrichs & Zakzanis, 1998; Mesholam-Gately, Giuliano, Goff, Faraone, & Seidman, 2009; Schretlen et al., 2007; Vöhringer et al., 2013). Specifically, impairments in verbal memory and processing speed have been proposed to be two of the most characteristic alterations among patients with SZ even in the early stages of the disease (Heinrichs & Zakzanis, 1998; Mesholam-Gately et al., 2009; Vöhringer et al., 2013). In the case of verbal memory, most of the

abnormalities have been identified especially in relation to new verbal learning and delayed memory (Mesholam-Gately et al., 2009; Saykin et al., 1991; Vöhringer et al., 2013). Furthermore, alterations in processing speed performance have been proposed as a core feature of the illness, due to its substantial deficit even when controlling for possible moderator variables of those alterations (Dickinson, Ramsey, & Gold, 2007; Knowles, David, & Reichenberg, 2010).

Although cognitive impairment seems to be present in most patients with SZ (Heinrichs & Zakzanis, 1998; Mesholam-Gately et al., 2009; Vöhringer et al., 2013), nowadays its discriminant accuracy has not been studied in this pathology. In recent years, there have been some attempts to address the inclusion of the presence of cognitive impairment in the 5th edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (American Psychiatric Association, 2013) as one of the principal diagnostic criteria for SZ (Barch & Keefe, 2010; Bora, Yucel, & Pantelis, 2010;Keefe, 2008; Keefe & Fenton, 2007). These authors support the idea that the inclusion of cognitive impairment into the DSM will help not only to obtain a more accurate diagnosis, but also to increase the "point of rarity" with other psychiatric diseases such as affective psychoses (Keefe, 2008; Keefe & Fenton, 2007). Previous studies have proven the utility of cognitive raw scores when discriminating between patients with SZ (Gonzalez-Blanch et al., 2011) and psychiatric and non-psychiatric population (Rojo et al., 2010) with and without cognitive impairment. However, despite preliminary attempts (Testa & Schretlen, 2006), no study has directly investigated cognitive scores' capability to discriminate between patients with SZ and healthy controls (HC) and the possible approaches to perform that discrimination in order to use them in the disease's diagnosis.

Some challenges have been pointed out related to the use of cognitive impairment as a diagnostic criterion (Barch & Keefe, 2010;Keefe, 2008; Keefe & Fenton, 2007). Perhaps, the most notable one is related to the need to reduce the cost and duration of the neuropsychological assessment of the cognitive status of the patient, which sometimes can be very expensive and time-consuming for both neuropsychologists and clinicians (Barch & Keefe, 2010; Keefe & Fenton, 2007). Additional challenges come from the difficulties encountered when trying to determine the presence of cognitive impairment that is inherent to the pathology and not caused by other confounding variables in patients with SZ (Keefe, 2008; Keefe & Fenton, 2007). One of the most commonly used methods to detect and identify the presence of cognitive impairment is that based on the comparison between patients' current cognitive scores and those obtained by a group of HC or observed in normative data (Kremen, Seidman, Faraone, Toomey, & Tsuang, 2000; Palmer et al., 1997; Reichenberg, 2010; Reichenberg et al., 2009; Schretlen et al., 2007). However, depending on the criteria applied when establishing a cut off, the percentage of patients with SZ classified as cognitively impaired can vary from 54 to 84% (Reichenberg et al., 2009). Consequently, some authors have proposed that cognitive impairment might be studied relative to each patient's predicted performance based on their premorbid functioning or socio-demographic variables (Wilk et al., 2005). One of the techniques used to obtain neuropsychological scores controlling for those socio-demographic and premorbid variables that could be having an influence on cognitive performance, is the regression-based approach (Schretlen, Testa, Winicki, Pearlson, & Gordon, 2008; Testa, Winicki, Pearlson, Gordon, & Schretlen, 2009). This methodology has already been used with respect to the Spanish population by Del Ser, González-Montalvo, Martínez-Espinosa, Delgado-Villapalos, & Bermejo (1997), in order to assess its application to the diagnosis of dementia. However, to our knowledge, no study has examined it in patients with SZ.

Key Points

1. Cognitive scores are useful and accurate when discriminating and classifying patients with schizophrenia and healthy controls.
2. Verbal memory scores better classify patients with schizophrenia when compared to healthy controls than do processing speed scores.
3. Raw cognitive scores seem to be better than discrepancy scores corrected for socio-demographic characteristics when classifying patients with schizophrenia and healthy controls.

Given that the presence of cognitive impairment could be of clinical utility in the diagnosis of patients with SZ, the present research aimed to study what would be the better approach when implementing that cognitive impairment in clinical practice. Therefore, the main objective of this study was to test the usefulness of cognitive raw scores to discriminate between patients with SZ and HC and their diagnostic utility. As a secondary objective, the study aimed to assess the discrimination ability of cognitive discrepancy scores (DS), obtained after controlling for socio-demographic and premorbid characteristics by means of regression-based norms, when comparing patients with SZ and HC. We hypothesized that raw cognitive scores would discriminate well between patients with SZ and HC. We also hypothesized that cognitive DS would discriminate and classify patients with SZ and HC better than would raw cognitive

scores, taking into account subject's socio-demographic and premorbid characteristics.

1 | METHOD

1.1 | Participants

A total of 258 patients with multi-episodic SZ were recruited. All the patients were assessed through a comprehensive neuropsychological battery. Patients were diagnosed with SZ based on the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders, 4th Edition, Text Revision (American Psychiatric Association, 2000) and excluded in case of: (a) having evidence of alcohol or drug abuse in the previous 30 days; (b) having a previous episode of loss of consciousness; (c) severe cognitive impairment; (d) substance dependence; or (e) having any relevant neurological or medical conditions. In addition, a subsample of 202 HC was included in this study. HC were also assessed through a comprehensive neuropsychological battery and excluded if they presented: (a) a medical history of physical or mental illness; (b) severe cognitive impairment; or (c) sensory limitations (visual or auditory) which could not be adequately compensated by corrections (glasses or hearing aids). The investigation was carried out in accordance with the latest version of the Declaration of Helsinki. Study was approved by the University of Deusto and the Basque Government Ethics Committees. All of the participants gave their written informed consent to participate in the study.

1.2 | Neuropsychological assessment

Both patients and HC underwent an extended neuropsychological battery. However, only scores on those tests common to both patients and HC could be included in the present study. For premorbid intelligence quotient (IQ), verbal memory, and processing speed those measures were: (a) the Word Accentuation Test (WAT), the Spanish version of the National Adult Reading Test, which consisted of 30 words to be read aloud with the correct accentuation by participants (Del Ser et al., 1997); (b) the Hopkins Verbal Learning Test-Revised (HVLT-R) (Benedict, Schretlen, Groninger, & Brandt, 1998), which is included in the MATRICS Consensus cognitive battery as a recommended measure of verbal learning (Nuechterlein et al., 2008); and (c) the Trail Making Test part A (TMT-A) (Reitan & Wolfson, 1985). In the present study, trials one, two and three were added and used as total recall verbal memory index, and the fourth trial was used as a delayed recall verbal memory index. TMT-A total time was used as a measure of processing speed.

1.3 | DS calculation by means of regression-based norms

Multiple linear regression analyses were performed on the HC group with the three cognitive variables (verbal memory total recall, verbal memory delayed recall and processing speed) as dependent variables and age, years of education and premorbid IQ as predictor variables in three separate analyses (one for each of the cognitive domains). Unstandardized B values were saved and used in a mathematical formula in order to obtain each participant's predicted scores in verbal memory total recall, delayed recall, and processing speed (see theoretical and applied formulas in Table 1). The DS for each of the cognitive variables were obtained by subtracting the predicted scores from the current scores of the participants, based on the methodology proposed by Testa et al. (2009).

1.4 | Statistical analyses

The Kolmogorov–Smirnov test was used to test the normal distribution of the variables. Sociodemographic variables (age, years of education and WAT scores) as well as TMT-A and HVLT-R total and delayed recall raw scores, and TMT-A and HVLT-R delayed recall DS showed a non-normal distribution, while HVLT-R total recall DS showed a normal distribution. Therefore, the subsequent statistical analyses were performed depending on normal or non-normal distribution. Differences in sex were assessed using the χ^2 test. Mann–Whitney U tests were performed in order to assess the differences in age, years of education, premorbid IQ, and neuropsychological variables between patients and HC. Multivariate analysis of covariance analyses were used to compare neuropsychological performance between

TABLE 1 Theoretical and applied formulas to calculate cognitive predicted scores based on the HC sample (HC = 202)

Theoretical formula: Predicted score = (Age B × Age raw score) + (Years of education B × Years of education raw score) + (Premorbid IQ B × Premorbid raw score) + K
Applied formulas: Verbal Memory Total Recall$_{predicted}$ = (−0.108 × Age) + (0.192 × years of education) + (0.237 × premorbid IQ) + 22.745
Verbal Memory Delayed Recall$_{predicted}$ = (−0.044 × Age) + (0.140 × years of education) + (0.166 × premorbid IQ) + 5.115
Processing Speed (recoded)$_{predicted}$ = (−0.433 × age) + (0.871 × years of education) + (0.937 × premorbid IQ) + (−56.913)

Abbreviations: B, unstandardized beta value; K, constant.

patients and HC, adding sex, years of education, and premorbid IQ as covariates. In order to assess the relationship between cognitive and socio-demographic and premorbid variables, Spearman's correlations were performed. Differences in DS between patients and HC were assessed using Student's *t* test or Mann–Whitney *U* test, as appropriate.

The receiver-operating characteristic (ROC) curve analysis was used as a method to evaluate the ability of the two different cognitive measures to classify and discriminate between patients with SZ and HC. ROC curve analysis was performed for raw and DS of each cognitive variable. Sensitivity (Se) and specificity (Sp) indices were obtained. Positive predicted values (PPV), negative predicted values (NPV) and accuracy were calculated based on the prevalence (Table 2). Effect sizes were calculated. All the analyses were performed using Microsoft Excel (2010) and SPSS 23.0 (SPSS Inc., Chicago, IL).

2 | RESULTS

2.1 | Demographic and neuropsychological differences

Sociodemographic and neuropsychological differences are shown in Table 3. Patients had lower scores than HC in verbal memory total recall and delayed recall indices, and they required a significantly longer period of time to complete the TMT-A. Effect sizes of these differences were from intermediate (TMT-A) to large (verbal memory learning and long term recall) (Table 3). When sex, years of education and premorbid IQ variables were added as covariates, the differences still remained significant except in the case of TMT-A (data not shown).

2.2 | Correlations between socio-demographic and neuropsychological variables

Correlation analyses between socio-demographic indices (age, years of education and premorbid) and neuropsychological measures (verbal memory total recall, verbal memory delayed recall, and processing speed) are shown in Table 4. In both patients with SZ and HC, the three cognitive variables correlated with age, years of education and premorbid IQ.

TABLE 2 Formulas used to calculate ROC curve properties

Prevalence: Number of patients with SZ/(number of healthy participants + number of patients with SZ)
PPV: Se × Prevalence/Se × Prevalence + (1 − Sp) × (1 − Prevalence)
NPV: Sp × (1 − Prevalence)/(1 − Se) × Prevalence + Sp × (1 − Prevalence)
Accuracy: (Se × Prevalence) + (Sp) × (1 − Prevalence)

Abbreviations: NPV, negative predicted value; PPV, positive predicted value; Se, sensitivity; Sp, specificity; SZ, schizophrenia.

2.3 | Differences in DS

As revealed by *t* tests, there were significant differences with large effect sizes between patients and HC in DS for verbal memory total recall ($p < .001$) and verbal memory delayed recall ($p < .001$). In this case, patients showed higher DS in these two measures when compared to HC. No significant differences were observed between DS of processing speed of patients and HC, although patients had higher values on this index (Table 5).

2.4 | ROC curve analyses

The results showed that regarding cognitive raw scores, all the cognitive domains discriminated between patients with SZ and HC. For verbal memory total recall, the area under the curve (AUC) had a value of 0.87 ($p < .001$) (Se = 0.82; Sp = 0.76.), 95% confidence interval (CI) [0.84, 0.90] (Figure 1). Verbal memory total recall raw scores showed a PPV of 81% and an NPV of 76% based on the existing prevalence (0.56), with 79% of accuracy. For verbal memory delayed recall, the AUC showed a value of 0.86 ($p < .001$) (Se = 0.75; Sp = 0.82.), 95% CI [0.82, 0.89] (Figure 2). PPV was 84% and a NPV 72%, with 78% of accuracy. AUC for the TMT-A time was lower but significant (AUC = 0.67 [$p < .001$]; [Se = 0.70; Sp = 0.58], 95% CI [0.62, 0.72]; 63% of accuracy) (Figure 3).

Regarding cognitive DS, only verbal memory total recall and delayed recall showed to have significant AUCs. Thus, for verbal memory total recall DS, the AUC had a value of 0.84 ($p < .001$) (Se = 0.89; Sp = 0.64.), 95% CI [0.81, 0.88] (Figure 1). Verbal memory total recall DS showed a PPV of 76% and a NPV of 82% based on the existing prevalence (0.56), with 78% of accuracy. Regarding verbal memory delayed recall DS, the AUC value was 0.80 ($p < .001$) (Se = 0.71; Sp = 0.79), 95% CI [0.75, 0.84], with 75% accuracy (Figure 2). PPV and NPV percentages were 81 and 68%, respectively. DS of TMT-A showed no significant AUC value (AUC = 0.54; $p = .181$) (Figure 3).

3 | DISCUSSION

Raw cognitive scores showed to be good discriminant indices when comparing patients with SZ and HC, confirming our first hypothesis. Specifically, verbal learning and delayed recall were the two best classifiers compared to processing speed. Moreover, both verbal learning and

TABLE 3 Socio-demographic and neuropsychological characteristics of the sample

		SZ ($N = 258$)	HC ($N = 202$)			
		M (SD) *N* (%)	M (SD) *N* (%)	U/χ^2	*p*	Cohen's *d*
Age		36.13 (10.04)	36.97 (16.52)	24,048.50	.155	0.13
Sex	Female	69 (27)	140 (69)	82.79	<.001	
	Male	189 (73)	62 (31)			
Years of education		10.28 (3.06)	14.23 (3.82)	10,746.00	<.001	1.17
Premorbid IQ		19.77 (5.31)	25.13 (3.62)	10,276.50	<.001	1.21
HVLT-R total recall		18.76 (6.35)	27.47 (4.33)	6,754.00	<.001	1.65
HVLT-R delayed recall		5.48 (3.07)	9.65 (2.24)	7,431.00	<.001	1.56
TMT-A time		53.38 (38.11)	36.99 (15.05)	17,192.50	<.001	0.61

Abbreviations: HC, Healthy controls; HVLT-R, Hopkins Verbal Learning Test Revised; M, mean; SD, Standard deviation; SZ, Schizophrenia; *U*, Mann-Whitney *U*; χ^2 Chi-square; IQ, Intelligence Quotient; TMT-A, Trail Making Test part A.

TABLE 4 Correlations between socio-demographic, premorbid and neuropsychological measures in patients with SZ and HC

Variables		Age	Years of education	Premorbid IQ	HVLT-R total recall	HVLT-R delayed recall	TMT-A time
SZ							
Age		-	−0.17**	0.07	−0.38**	−0.33**	0.48**
Years of education		−0.10	-	0.29**	0.36**	0.30**	−0.23**
Premorbid IQ		0.16*	0.32**	-	0.27**	0.23**	−0.30**
HVLT-R total recall	HC	−0.35**	0.35**	0.19**	-	0.74**	−0.55**
HVLT-R delayed recall		−0.30**	0.43**	0.28**	0.67**	-	−0.52**
TMT-A time		0.34**	−0.37**	−0.22**	−0.34**	−0.24**	-

Abbreviations: HC, Healthy controls; HVLT-R, Hopkins Verbal Learning Test Revised; IQ, Intelligence quotient; SZ, Schizophrenia; TMT-A, Trail Making Test part A.
*$p < 0.05$; **$p < 0.01$.

TABLE 5 Differences in DS

	SZ ($N = 258$)	HC ($N = 202$)			
Variables	*M (SD)*	*M (SD)*	*t/U*	*p*	Cohen's *d*
HVLT-R total recall DS	−6.874 (5.58)	0.03 (3.64)	−15.68	<.001	1.43
HVLT-R delayed recall DS	−2.77 (2.77)	0.00 (1.85)	10,684.00	<.001	1.18
TMT-A time DS	8.29 (34.36)	0.01 (11.52)	24,164.00	.18	0.13

Abbreviations: DS, Discrepancy Scores; HC, Healthy controls; HVLT-R, Hopkins Verbal Learning Test Revised; M, mean; SD, Standard deviation; SZ, Schizophrenia; *t*, Student's *t*-test; *U*, Mann-Whitney *U*; TMT-A, Trail Making Test part A.

delayed recall were demonstrated to discriminate between patients and HC with an accuracy of around 80%. Sensitivity and specificity indices were especially good for verbal learning, and this measure was shown to classify 81.7% of the patients as patients with SZ and 75.6% of the HC as not having any diagnosis. Supporting these results, verbal memory has been identified as one of the most affected cognitive domains in patients with SZ when comparing their cognitive performance to that in HC, even in drug naïve patients (Aleman, Hijman, de Haan, & Kahn, 1999; Fatouros-Bergman, Cervenka, Flyckt, Edman, & Farde, 2014; Heinrichs & Zakzanis, 1998). Thus, it would be reasonable to think that performance on this cognitive domain might be a useful tool to help in clinical diagnosis of patients with SZ.

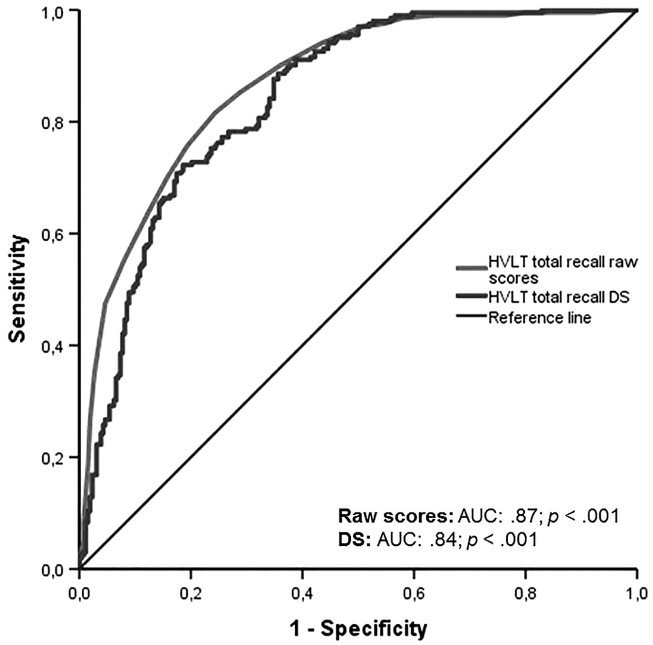

FIGURE 1 ROC HVLT-R total recall raw and discrepancy scores

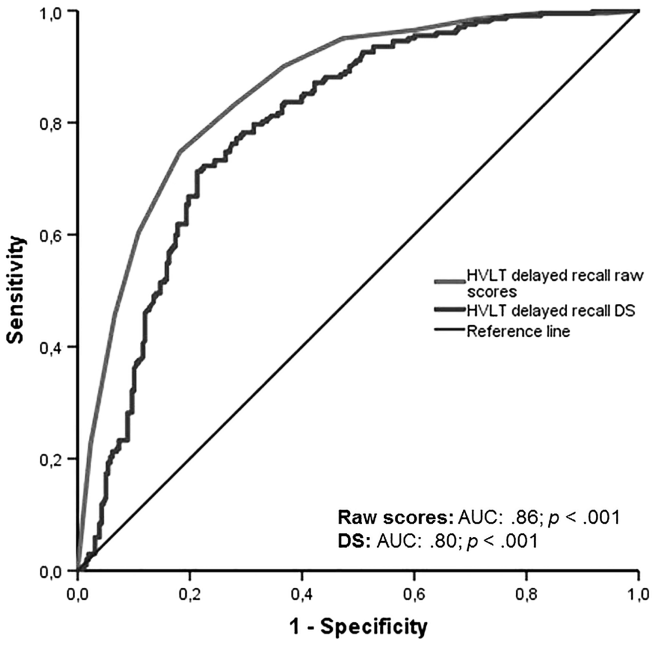

FIGURE 2 ROC HVLT-R delayed recall raw and discrepancy scores

Regarding processing speed, TMT-A showed a poor to fair value of AUC and a lower index of accuracy compared with verbal memory, indicating that processing speed might not be a good index in order to discriminate and classify patients with SZ and HC. These findings contrast with the conceptualisation of processing speed as one of the most affected cognitive domains in patients with SZ (Fatouros-

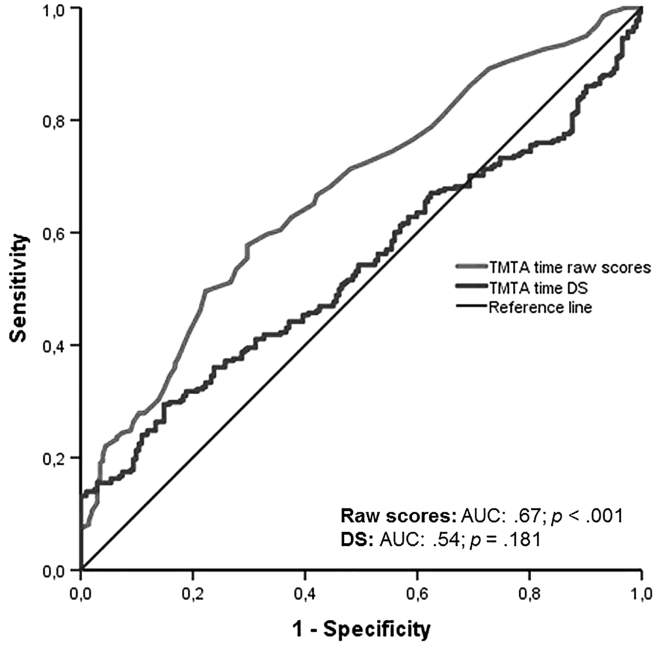

FIGURE 3 ROC TMT-A time raw and discrepancy scores

Bergman et al., 2014; Heinrichs & Zakzanis, 1998; Schaefer, Giangrande, Weinberger, & Dickinson, 2013). The present results might be explained in relation to the measure (TMT-A) rather than to the cognitive domain itself. On this line, the present findings are supported by another study which pointed out that specifically raw measures derived from the TMT-A have poor sensitivity when discriminating between patients with first-episode SZ with and without marked cognitive impairment (Gonzalez-Blanch et al., 2011).

Consistent with our results, measures included in the Screen for Cognitive Impairment in Psychiatry (SCIP; Purdon, 2005) cognitive battery (Rojo et al., 2010) to assess verbal memory and processing speed were shown to be good at discriminating between patients with SZ, bipolar disorder and HC with and without cognitive impairment. However, in the afore mentioned study, processing speed (measured using the TMT-A, Digit Symbol-Coding test and the Symbol Search test) was the measure that better discriminated between participants with and without cognitive impairment, over verbal learning and memory. These findings might suggest that a more complex measure of processing speed could be better than one measure alone in discriminating psychiatric patients from HC. Regarding memory, and taking into account the screening nature of the SCIP, verbal memory measures showed higher NPV over PPV, supporting their use as cognitive screening tools. On the contrary, the present results showed higher PPV over NPV on both HVLT-R learning and delayed recall trials, generating more false negatives in favour of less false positive rates. This is an important feature to take into account when designing and choosing diagnostic tools, in order to avoid over-diagnosis

of the pathology and when promoting accurate instruments for assessment.

It is noteworthy that AUC values obtained in the present study, and especially those of verbal learning scores, are very similar to those presented by Ritsner, Mar, Arbitman, & Grinshpoon (2013), when assessing the capability of the the Positive and Negative Syndrome Scale to discriminate between psychotic patients and mood disorder patients based on their clinical symptoms. The positive and negative syndrome scale is a well-recognised measure, which is sometimes used even in the diagnosis of SZ. Therefore, raw cognitive scores of the HVLT-R might be used as a reliable discriminant index, highlighting its potential role in the diagnosis of SZ.

Regarding our second hypothesis, contrary to our expectations, results showed that cognitive DS did not discriminate and classify patients with SZ and HC better than did raw cognitive scores. Among the cognitive DS, only those from verbal memory learning and delayed recall showed significant AUCs and, therefore, could discriminate well between patients and HC. However, they were worse than raw scores. Thus, the present results point out that, despite the fact that cognitive DS would seem more accurate cognitive measures, these do not discriminate better between patients with SZ and HC than do raw scores, at least in this sample. These findings contrast with preliminary results, which indicated that those DS obtained by means of regression-based approach showed increased sensitivity without reducing specificity when classifying patients with SZ and HC (Testa & Schretlen, 2006).

One possible explanation for results regarding DS might rely on the controlled variables, especially years of education and premorbid IQ. Thus, whereas in neurodegenerative diseases such as dementia, premorbid IQ usually tends to be preserved (McGurn et al., 2004), in neurodevelopmental pathologies this index may be impaired due to the early age of onset of the disease (Khandaker, Barnett, White, & Jones, 2011). Specifically in SZ, premorbid IQ has been shown to be impaired even in stages prior to the onset of the disease (Khandaker et al., 2011). In the same way, patients with SZ generally have less years of education than do HC since the disease usually truncates their educational achievement (Resnick, 1992). As such, by eliminating premorbid IQ and years of education effect by means of regression-based approach to obtain DS, those differences in cognitive performance might diminish, and even disappear as in the case of processing speed. This is also noted in effect sizes. Thus, this decreased magnitude of the differences might be pointing to a reduced discriminant capability of DS when classifying patients and HC. Although useful, and taking into account their time-consuming nature, the use of DS might not be the most suitable approach when trying to discriminate patients with neurodevelopmental pathologies and HC.

The results of this study must be seen in the context of some limitations. Firstly, the present results can only be generalised with caution to patients in different stages of the disease, such as first-episode patients. While the magnitude and pattern of the observed cognitive impairment in different stages of the disease are similar, some differences have been reported (Mesholam-Gately et al., 2009). Secondly, DS have been calculated based on beta weights derived from the same sample of HC that is later used for the rest of the analyses, which might be affecting DS values. Thirdly, and as previously discussed, taking into account the etiopathogenesis of the disease, premorbid IQ and years of education in patients with SZ may be affected by the onset of the illness itself, reducing the discriminant capability of the DS. Fourthly, the lack of a psychiatric control group makes it impossible to determine if the present cognitive impairments are specific to SZ and, therefore, represent a "point of rarity" of this pathology. Finally, the present findings are also constrained because of the inclusion of only two neuropsychological variables, limiting its conclusions. Future studies should investigate if present results are also found in relation to other cognitive variables also impaired in patients with SZ such as attention or planning.

Future studies should try to replicate these results in other pathologies, especially in neurodegenerative diseases and investigate if DS are more useful than raw scores when discriminating patients with neurodegenerative diseases. In addition, further research might explore the role of DS on discriminating patients with SZ and HC controlling for other socio-demographic or premorbid variables such as parental socio-economic status, instead of years of education, as it has been previously suggested (Meehl, 1970; Resnick, 1992). Finally, it would be of major interest to study whether cognitive raw scores can discriminate between patients with SZ and other psychiatric diseases such as schizoaffective or bipolar disorder in order to establish the diagnostic specificity of these measures.

Overall, cognitive DS controlling for premorbid and socio-demographic variables, seem not to be better classification indices than are raw scores at least when discriminating patients with neurodevelopmental pathologies such as SZ. However, good discriminant indices obtained by the raw scores of the HVLT might support the previous attempts to include the presence of cognitive impairment as a diagnostic criterion in diagnostic manuals such as the DSM.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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