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Neurocognitive, social cognitive, and clinical predictors of creativity in schizophrenia

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ABSTRACT

Background: Creativity is considered an essential human accomplishment and a key component for daily life problem solving. It has been suggested that impairment in working memory, cognitive flexibility, and theory of mind could lead to lower creativity in schizophrenia. Additionally, other neurocognitive and social cognitive domains, as well as clinical symptoms could play a role in this relationship. However, the extent to which each of these domains influences creativity in schizophrenia remains unknown. Therefore, the aim of this study was to simultaneously investigate the specific contribution of neurocognitive, social cognitive, and clinical variables to creativity in schizophrenia.

Methods: One hundred and one patients with schizophrenia were assessed in terms of sociodemographic, clinical, neurocognitive, social cognitive, and creativity variables.

Results: After controlling for sociodemographic variables, regression analyses showed that higher social perception ($\beta = 0.286$, $p = .004$) and processing speed ($\beta = 0.219$, $p = .023$) predicted creativity total score. Higher social perception ($\beta = 0.298$, $p = .002$) and processing speed ($\beta = 0.277$, $p = .004$) explained figural creativity. Finally, lower negative symptoms ($\beta = -0.302$, $p = .002$) and higher social perception ($\beta = 0.210$, $p = .029$) predicted verbal creativity.

Conclusions: Results suggest that neurocognitive, social cognitive, as well as clinical symptoms influence creativity of patients with schizophrenia. Moreover, these findings point out the prominent role of social cognition in creativity in schizophrenia.

1. Introduction

Creativity is perceived as a very complex human capacity and it is considered one of most important human accomplishments (Pick and Lavidor, 2019). In addition, it is a key component for daily life problem solving (Plucker et al., 2015) and it seems to have an impact on academic and workplace performance (Rindermann and Neubauer, 2004). Creativity is defined as the capacity to generate something that is original and appropriate (Sternberg and Lubart, 1995). One of the most important component of creativity is divergent thinking. Divergent thinking involves the capacity to establish distant associations between unrelated ideas from different categories and proposing multiple answers to a problem (Guilford, 1967). It is a multifaceted concept composed of diverse dimensions such as originality, fluency or flexibility (Guilford, 1967). An intriguing topic in this context concerns the relationship between psychopathology and creativity, which has been considered the oldest and most controversial topic in the behavioral sciences (Becker, 2014). However, nowadays the debate remains open

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(Simonton, 2019). Although there are well-known cases of highly creative people who showed schizophrenic symptoms and few empirical studies (Glicksohn et al., 2001) that support this idea, a recent meta-analysis (Acar et al., 2017) concluded that schizophrenia is negatively associated with creativity.

In an attempt to understand the reasons for creativity impairment in schizophrenia, several authors have suggested the role of other neurocognitive functions (Abraham et al., 2007; Carson, 2011; Jaracz et al., 2012). This idea has been supported by the Shared Vulnerability Model proposed by Carson (2011). According to this model, creativity and psychopathology share several genetic vulnerability factors, which would encourage accessibility to the associational ideas that are normally processed out of consciousness. This enhanced accessibility could promote creativity, or instead constitute a risk for psychopathology, depending on the presence of several risk factors (Carson, 2011). The risk factors that would encourage psychopathology rather than creative thinking are working memory (WM) deficits, low intelligence quotient (IQ), and an impaired cognitive flexibility (CF) (Carson, 2011). In sum, it seems that the creative capacity of people with schizophrenia could be negatively affected by their impairment in multiple neurocognitive functions.

Regarding CF, this can be defined as the ability to flexibly switch focus of attention, perspectives, strategies, or response mappings (Diamond, 2013, 2006). It is usually assessed with task-switching paradigms (Diamond, 2013), such as the Modified Wisconsin Card Sorting Test (M-WCST; Schretlen, 2010), the Intra-/Extra-Dimensional set-shift task of the Cambridge Neuropsychological Test Automated Battery (Robbins et al., 1994), or the Dimensional Change Card Sort Test (Zelazo, 2006). Additionally, CF can be measured through design, verbal and semantic fluency tests (Diamond, 2013), such as the Five Point Test (Regard et al., 1982) or the Calibrated Ideational Fluency Assessment (Schretlen and Vannorsdall, 2010). Previous studies found both lower CF and creativity in schizophrenia compared to healthy people (Abraham et al., 2007; Jaracz et al., 2012; Sampedro et al., 2019). Besides, Abraham et al. (2007) and Sampedro et al. (2019) found that CF mediated creativity in people with schizophrenia. With respect to studies carried out on healthy people, in general, a positive association between CF and creativity has been found (Krumm et al., 2018; Nusbaum and Silvia, 2011; Pan and Yu, 2016; Wang et al., 2017; Zabelina and Robinson, 2010), although non-significant associations have also been reported (Benedek et al., 2014b). These inconsistencies suggest that the role of CF in creativity may depend on the cognitive demands of the particular creative task (Lee and Therriault, 2013). It has been suggested that while CF seems necessary to produce new ideas (by switching from concept to concept) (Nijstad et al., 2010; Pan and Yu, 2016), other cognitive functions such as inhibitory control may be required to suppress salient and less original ideas and focus on novel information (Edl et al., 2014). Previous studies have showed a correlation between creativity and inhibitory control (Benedek et al., 2014b, 2012; Edl et al., 2014; Groborz and Necka, 2003), but also a negative relationship (Carson et al., 2003; Radel et al., 2015).

The second relevant function according to the Shared Vulnerability Model is WM (Carson, 2011) Two studies have explored this hypothesis in people with schizophrenia (Abraham et al., 2007; Sampedro et al., 2019). WM allows an individual to keep a large amount of associational material in mind without being overwhelmed by it (Carson, 2011). Additionally, WM may help with maintaining the novel information activated and distinguishing relevant ideas from irrelevant ones for the creative task (de Dreu et al., 2012). Several studies conducted with healthy people have also found a positive association between creativity and WM (Benedek et al., 2014b; de Dreu et al., 2012; Oberauer et al., 2008).

There are two main neurocognitive domains highly impaired in schizophrenia that have not been included in the Shared Vulnerability Model: processing speed (PS) (Kochunov et al., 2016) and verbal memory (VM) (Brébion et al., 2013). PS is considered a basic cognitive domain and assumed to underlie other higher order cognitive functions in schizophrenia (Ojeda et al., 2012). In healthy people, PS also seems to underlie creativity (Forthmann et al., 2018; Rindermann and Neubauer, 2004; Vartanian et al., 2009). A possible reason may be that higher PS provides a faster access to memory while working on a task and, therefore, improves creative thinking (Preckel et al., 2006). In relation to VM, it has been suggested that memory retrieval plays an important role in the generation of creative ideas in healthy people (Benedek et al., 2014a; Gilhooly et al., 2007). When generating new ideas one needs to access the internal knowledge representations through a controlled retrieval in order to recombine this stored knowledge (Benedek et al., 2014a). Nevertheless, the association between the performance in a memory retrieval task (e.g., short VM task) and creativity has scarcely been studied, and both positive (Polner et al., 2018) and non-significant associations (Moreno et al., 2017) have been found so far.

Although the Shared Vulnerability Model did not include social cognitive domains, such as theory of mind (ToM), social perception (SP), or emotion processing (EP), a recent study found that the low creativity shown by patients with schizophrenia was partially mediated by ToM (Sampedro et al., 2019). There is additional evidence of a positive association between ToM and creativity in healthy people (Sigirtmac, 2016; Suddendorf and Fletcher-Flinn, 1999, 1997). As suggested by Suddendorf and Fletcher-Flinn (1997), the meta-representational skills required for ToM may be needed to understand other people's minds and also to analyze one's own mind. These meta-representational skills may allow individuals to consider information from different points of view, and therefore, to conceive diverse representations of the same object at the same time as well as to consider different alternative solutions for a problem. In addition to the meta-representational skills, Abraham (2019) suggested three other common mechanisms which are 1) intention to communicate, 2) intention to understand, and 3) personal relevance bias. Furthermore, the association between creativity and social cognition is reinforced by neuroimaging studies, which indicate that common brain regions, such as the default mode network, are engaged in both creativity (Beaty et al., 2016) and social cognition processes like ToM (Li et al., 2014). As far as the authors are aware, none of the previous studies has explored this relationship with other dimensions of social cognition such as SP or EP.

Another factor that may influence the creativity of people with schizophrenia is clinical symptomatology. Most literature about schizotypal personality and creativity suggests that positive schizotypy, in contrast to negative schizotypy, is related to higher creativity (Fisher et al., 2004). However, studies carried out with people with schizophrenia have not found very consistent results (Abraham et al., 2007; Jaracz et al., 2012; Son et al., 2015). For example, Son et al. (2015) did not find any significant correlation between creativity and positive symptoms. Abraham et al. (2007) found thought disorder to be significantly related to lower scores in some creativity indexes. With respect to negative symptoms, they did not find any significant correlation with creativity (Abraham et al., 2007). On the other hand, Jaracz et al. (2012) only found significant associations between creativity and negative symptoms, but not with positive symptoms. However, none of these studies included one of the new instruments for negative symptom assessment proposed by the NIMH-MATRICS Consensus Statement on Negative Symptoms (Carpenter et al., 2016; Kirkpatrick et al., 2006).

The understanding of which domains underlie creativity in schizophrenia is crucial, since this capacity has shown to be a key factor for real-life problem solving (Plucker et al., 2015) and essential for dealing with daily life adversities (Flood and Scharer, 2006). In fact, the impaired creative capacity found in schizophrenia (Acar et al., 2017) could be negatively influencing daily functioning of these people. This means that the improvement of creativity could become a treatment target. For this reason, knowing the underpinnings of creativity could be essential for the development of cognitive rehabilitation programs aimed to improve this capacity and in turn daily life functioning and quality of life of patients with schizophrenia.

Altogether, previous evidence suggests that the creativity of people with schizophrenia could be altered due to an impairment of multiple cognitive functions and the possible influence of some clinical factors. However, the extent to which each domain influences creative thinking in this pathology is still unknown. Therefore, the aim of this study was to simultaneously analyze the predictive value of neurocognitive, social cognitive, and clinical symptoms on creativity in schizophrenia. In line with previous literature, we hypothesized that creativity of patients with schizophrenia would be partly explained by different factors including clinical, neurocognitive, and social cognitive variables. Regarding clinical symptoms, it was hypothesized that these would be negatively associated with creativity. With respect to neurocognitive and social cognitive variables, it was hypothesized that these would be positively related to creativity.

2. Methods

2.1. Participants

One hundred and nineteen patients diagnosed with schizophrenia were recruited from the Psychiatric Hospital of Álava and the Mental Health Network in Álava (Spain). Patients from the study met the diagnostic criteria for schizophrenia according to the Structured Clinical Interview for DSM-V (the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition; American Psychiatric Association, 2013). Exclusion criteria consisted of: a) cognitive impairment secondary to another disease: b) clinical instability (total score in PANSS-Positive > 19); c) significant changes in the antipsychotic treatment in the previous three months; d) main diagnosis of Substance Use Disorder or presenting active drug consumption at the time of the study; and e) diagnosis of an active Major Affective Disorder.

One patient was excluded due to exclusion criteria and 17 patients refused to participate, therefore the final sample consisted of 101 patients (82 males and 19 females) (see Fig. 1 for the flow diagram). The mean age was 41.55 (SD = 10.05) years old, mean years of education was 10.22 (SD = 2.60), and mean premorbid IQ was 94.56 (SD = 10.19). Of the sample, 76.23% were right-handed, 3.96% left-handed, and 19.8% mixed-handed. Mean age of onset of the disease was 23.28 (SD = 6.23), with a mean of previous hospitalizations of 6.93 (SD = 7.18) and a mean of medication dosage (chlorpromazine equivalent doses - mg/day) of 493.43 (SD = 281.96). Medication was changed to chlorpromazine by using the defined daily dose method (Leucht et al., 2016; Rothe et al., 2018).

The study protocol was approved by Clinical Research Ethics Committees of the Autonomous Region of the Basque Country (CEIC-E) in Spain (PI2017044). The study was carried out in accordance with the latest version of the Declaration of Helsinki. All participants took part voluntarily. They provided written informed consent to participate and they did not receive any monetary reward for taking part in the study. The trial was registered in clinicaltrials.gov (NCT03509597).

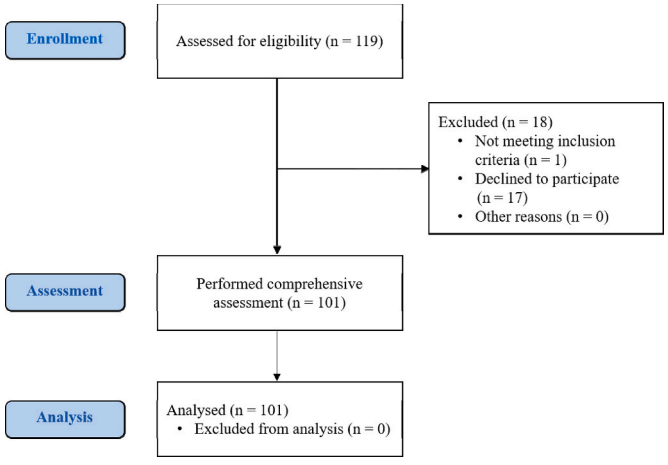

Fig. 1. Flow diagram.

2.2. Measures

The complete evaluation of the study took approximately 2 h and 5 min; 1 h and 20 min for the assessment of creativity and cognition and 45 min for the clinical part. The clinical and neuropsychological (cognition and creativity) evaluations were conducted on different days. Since this study is part of a larger project (clinical trial NCT03509597), the whole assessment protocol took approximately 2 h and 50 min.

2.2.1. Creativity

Figural and verbal creativity were assessed with two subtests from the Torrance Test of Creative Thinking (Torrance, 1966, 2016): the *Picture Completion* subtest for figural creativity and the *Unusual Uses* subtest for verbal creativity. Four minutes were given to complete each task. The *Picture Completion* subtest consisted of completing ten unfinished pictures by producing as many ideas as possible and including a title to each picture. The following dimensions were assessed from this task: originality, fluency, elaboration, resistance to premature closure, and abstractness of titles. Originality measured the ability to produce unusual or statistically infrequent responses. Responses were classified as original (1 point) or unoriginal (0 points) according to the list that had been developed for each item on the basis of normative data (Torrance, 1966, 2016). Fluency was defined as the number of relevant responses produced, awarding 1 point to each figure completed. Elaboration consisted on the number of details added to a figure. Each detail was awarded 1 point. Resistance to premature closure was based on the ability to quickly resist closing the incomplete figures. Scores could range from 0 (quick closure and no resistance to closure) to 2 (incidental or no closure, resistance to closure) for each figure. Abstractness of titles was defined as the degree to which a title moved beyond concrete labeling. A four-point scale (0–4) was used to score titles. Total figural creativity score was obtained through the sum of these five subdimensions. Additionally, a figural creative strengths score was calculated based on the manual (Torrance, 2016). Figural creative strengths consisted of 11 criterion-referenced measures: emotional expressiveness, storytelling articulateness, movement or action, expressiveness of titles, synthesis of incomplete figures, unusual visualization, internal visualization, humor, richness of imagery, colorfulness of imagery, and fantasy. Each creative strength was assigned 1 point.

The *Unusual Uses* subtest consisted of writing as many unusual uses as possible for cardboard boxes. Originality, flexibility, and fluency dimensions were measured in this task. Originality was scored using the list of items from the manual (Torrance, 1966, 2016), assigning 1 point for original or uncommon responses and 0 points for unoriginal responses. Flexibility consisted of the number of different categories represented in the responses, giving 1 point to each category. Fluency was defined as the total number of unusual uses generated, awarding 1 point to each unusual use. The sum of these three dimensions was used to calculate the total verbal creativity score.

In addition to these individual figural and verbal scores, a total general creativity score was obtained using the Z-scores of all verbal and figural subdimensions (Cronbach's alpha = 0.79), following the Torrance Test of Creative Thinking scoring system (Torrance, 1966). Since the scoring procedure of creative strengths was different from the other subdimensions, this was not included in the total composite score.

2.2.2. Neurocognition

Neurocognitive functioning was assessed by the following domains: CF, inhibition, WM, VM, and PS. All neurocognitive scores were converted into Z-scores based on the sample of the study. Some scores were adjusted so that higher scores indicated better cognitive performance.

CF was assessed using a composite score obtained from the number of categories completed and the number of perseverative errors from the M-WCST (Schretlen, 2010) (Cronbach's alpha = 0.77). Stroop Word-Color and Stroop Interference values from the Stroop Color and Word Test (Golden, 2010) was used for the assessment of inhibition (Cronbach's alpha = 0.80). WM was measured by the Backward Digit Span subtest from the Wechsler Adult Intelligence Scale-III (WAIS-III; Wechsler, 1997). The three learning trials and the delayed recall trial from the Hopkins Verbal Learning Test (HVLT version 2; Brandt and Benedict, 2001) was used for the measurement of VM (Cronbach's alpha = 0.84). PS was measured by a composite obtained from the Stroop Word, Stroop Color (Golden, 2010) and the number of correct symbols from the Symbol-Coding subtest from the Wechsler Adult Intelligence Scale-III (Wechsler, 1997) (Cronbach's alpha = 0.74).

2.2.3. Social cognition

Three domains of social cognition were evaluated: ToM, SP, and EP. ToM was measured with the Happé Test "Strange Stories Task" (Happé, 1994). From the Happé test, four stories were used. SP was assessed with the Social Attribution Task-Multiple Choice II (SAT-MC-II; Johannesen et al., 2013). EP was assessed using the Spanish adaptation of the Bell Lysaker Emotion Recognition Test (BLERT; Bell et al., 1997).

2.2.4. Clinical symptoms

Psychopathology was measured using the Brief Negative Symptom Scale (BNSS; Kirkpatrick et al., 2011) and the Positive and Negative Syndrome Scale (PANSS; Kay et al., 1987). The Positive Scale, Negative Scale, and General Psychopathology Scales were sourced from the PANSS. Additionally, awareness of mental disorder was assessed by the Scale of Unawareness of Mental Disorder (SUMD; Amador et al., 1993). A total awareness of mental disorder score was obtained with the three general items of the scale (Cronbach's alpha = 0.93): awareness of mental disorder, awareness of the effects of medication, and awareness of the social consequences of the disorder.

2.2.5. Premorbid IQ

Premorbid IQ was assessed by means of the Accentuation Reading Test (TAP; Del Ser et al., 1997), a Spanish version of the National Adult Reading Test (Nelson and Willison, 1991). Raw scores were converted using the full scale IQ of Gomar et al. (2011) in order to estimate premorbid IQ.

2.2.6. Handedness

The Edinburgh Handedness Inventory (Oldfield, 1971) was used to measure handedness. Handedness consistency was calculated using a formula (right − left/right + left) and the obtained scores ranged from 100 (wholly right-handed) to −100 (wholly left-handed). Participants who obtained scores ranging from −79 to 79 were considered to be mixed handed, and those with scores ranging from −100 to −80 or from 80 to 100 to be consistent handed.

2.3. Data analyses

Statistical analyses were carried out by IBM SPSS version 26.0 (SPSS Inc., Chicago, USA). The Kolmogorov-Smirnov test was used to test data for normality. Spearman's Rho and Pearson's *r* correlations were performed between sociodemographic, clinical, neurocognitive, social cognitive, and creativity variables. Multiple testing correction was performed in the correlation analyses using the Benjamini-Hochberg false discovery rate method (Benjamini and Hochberg, 1995). The resulting adjusted significance level was 0.010. Stepwise Multiple Regression analyses were performed to determine which variables predict creativity. In the regression analyses, those sociodemographic, clinical, neurocognitive, and social cognitive variables which correlated significantly with each creativity score were included. With regard to negative symptoms, the BNSS was included instead of the PANSS-Negative, as recommended by the NIMH-MATRICS Consensus Statement on Negative Symptoms (Carpenter et al., 2016; Kirkpatrick et al., 2006). As creativity variables did not follow a normal distribution, these were transformed (through LN or square-root transformation) to carry out regression analysis, except for total creativity variable which followed a normal distribution. Figural strengths variable was not entered in the regression analysis since this variable did not follow a normal distribution after its transformation. Multicollinearity in the regression analyses was evaluated through the variance inflation factor (VIF) and tolerance statistics. According to Kleinbaum et al. (1988), VIF $\geq$ 10 and tolerance $\leq$ 0.10 would indicate collinearity problems. No multicollinearity (tolerance and VIF statistics) among measures was found. Significance level was set at 0.05. All tests were two-tailed.

Since participants were assured that the raw data would be kept confidential and not shared, the study data are not available in the public domain.

3. Results

The average performance scores on clinical, neurocognitive, social cognitive, and creativity tests can be found in Supplemental Table S1. Correlation analyses were performed between sociodemographic, clinical, neurocognitive, social cognition, and total creativity scores (Table 1) as well as with creativity subdimensions (Supplemental Table S2). Correlations between clinical, neurocognitive, and social cognition variables are detailed in Supplemental Table S3. Correlation analyses between creativity subdimensions can be seen in Supplemental Table S4. Additionally, regression analyses were carried out including

Table 1
Correlations between sociodemographic, clinical, neurocognitive, social cognitive, and creativity variables.

	Patients with schizophrenia (N = 101)			
	Total creativity	Figural creativity	Figural strengths	Verbal creativity
Sociodemographic and clinical characteristics				
Sex (female)	.058	.111	.067	.011
Age	-.032	-.144	-.175	.032
Years of education	.286*	.245	.225	.274*
Handedness	.056	-.072	-.097	.066
Age of onset	-.085	-.214	-.299*	-.021
Previous hospitalizations	-.172	-.058	.040	-.190
Premorbid IQ	.195	.230	.241	.167
Medication dosage	-.099	-.188	-.200	.009
PANSS Positive	-.074	-.118	-.033	-.091
PANSS Negative	-.187	-.222	-.257*	-.300*
PANSS General	-.101	-.120	-.232	−108
PANSS Total	-.148	-.182	-.217	-.183
BNSS	-.287*	-.238	-.245	-.396**
SUMD	-.180	-.130	-.074	-291*
Neurocognition				
CF	.141	.149	.167	.104
Inhibition	.078	.194	.158	.024
WM	.122	.249	.312*	.151
VM	.078	.127	.099	.161
PS	.330**	.421**	.322**	.241
Social cognition				
ToM	.278*	.319**	.367**	.258*
SP	.393**	.403**	.263*	.328**
EP	.244	.307*	.407**	.198

Figural creativity and verbal creativity variables are the sum of each figural and verbal dimension, respectively. Total creativity is the average of all creative scores. Medication dosage refers to chlorpromazine equivalent doses (mg/day). PANSS = Positive and Negative Syndrome Scale; BNSS = Brief Negative Symptom Scale; SUMD = Scale of Unawareness of Mental Disorder; CF = Cognitive Flexibility; WM = Working Memory; VM = Verbal Memory; PS = Processing Speed; ToM = Theory of Mind; SP = Social Perception; EP = Emotion Processing. Values were adjusted by Benjamini-Hochberg's correction .010. *$p \leq .010$; **$p \leq .001$.

only those variables that correlated significantly with each creativity variable. Regressions with sociodemographic, clinical, neurocognitive, and social cognitive data can be seen in Tables 2 and 3. With regard to total creativity scores (Table 2), higher SP and PS predicted total creativity. Higher SP and PS explained figural creativity. Verbal creativity was predicted by lower negative symptoms, measured through BNSS, and higher SP.

With respect to creativity subdimensions (Table 3), higher PS and ToM predicted figural elaboration. Abstractness of titles was explained by higher ToM, WM, and PS. Verbal originality was predicted by higher SP and lower negative symptoms. Higher ToM and PS explained verbal flexibility. Finally, verbal fluency was predicted by lower negative symptoms. The rest of the creativity subdimensions showed no significant correlation with clinical and cognitive variables, so regression analyses were not carried out with them.

4. Discussion

The aim of this study was to analyze the predictive value of neurocognition, social cognition, and clinical symptoms on creativity in patients with schizophrenia. To our knowledge, this is the first study simultaneously exploring the effect of neurocognitive functions (CF, WM, PS and VM), social cognitive domains (SP, ToM and EP), and clinical symptoms, controlling for several sociodemographic variables (age, years of education, handedness, previous hospitalizations, premorbid IQ, and medication dosage). Our hypothesis was partially fulfilled. Regarding clinical symptoms, only negative symptoms were negatively related to creativity. With respect to cognitive variables, only some neurocognitive functions, although all social cognitive domains were positively associated with creativity.

Regression analyses showed that higher PS and WM predicted higher creativity. The association between WM and creativity is in line with previous research carried out with both people with schizophrenia (Abraham et al., 2007; Sampedro et al., 2019) and healthy people (Benedek et al., 2014b; de Dreu et al., 2012; Oberauer et al., 2008). As suggested by the Shared Vulnerability Model (Carson, 2011), an impaired WM is one of the risk factors that could lead to lower creativity in schizophrenia. PS has also been related to creativity in healthy people (Forthmann et al., 2018; Rindermann and Neubauer, 2004; Vartanian et al., 2009) and it has been shown to underlie other higher order cognitive functions in schizophrenia (Ojeda et al., 2012). Thus, the impairment in PS found in this disease (Kochunov et al., 2016) could be another factor causing reduced creative thinking. With respect to the other neurocognitive domains analyzed (CF, inhibition, and VM), unexpectedly, these did not correlate significantly with creativity. Other studies have also found non-significant associations between creativity and CF (Benedek et al., 2014b), inhibition (Burch et al., 2006; Green and Williams, 1999; Stavridou and Furnham, 1996), and VM (Moreno et al., 2017). However, contrary to this study, previous literature have also found positive associations between creativity and CF (Krumm et al., 2018; Nusbaum and Silvia, 2011; Pan and Yu, 2016; Wang et al., 2017; Zabelina and Robinson, 2010), inhibition (Benedek et al., 2014b, 2012; Edl et al., 2014; Groborz and Necka, 2003), and VM (Polner et al., 2018). These conflicting results could be partly due to the different instruments used for the assessment of these variables across studies. Another possible explanation is that the non-significant associations in this study appeared after correcting the correlation analyses for multiple comparisons, a method that has not been applied in all previous studies.

With regard to social cognition, ToM, SP, and EP correlated significantly with creativity. Besides, regression analyses showed that higher ToM and SP predicted higher creativity. As mentioned before, to date, the association between creativity and social cognition has only been studied with ToM. The few studies available about the topic have also found a positive relationship between creativity and ToM in both healthy people (Sigirtmac, 2016; Suddendorf and Fletcher-Flinn, 1999, 1997) and people with schizophrenia (Sampedro et al., 2019). However, as far as the authors are aware, no study has analyzed this with SP and EP. These results suggest that other social cognition domains are involved in creative thinking in addition to ToM. Therefore, the connection between creativity and social cognition may not be limited only to the capacity for meta-representation, but may also underlie other common processes, such as those suggested by Abraham (2019): intention to communicate, intention to understand, and personal relevance bias. Moreover, although creativity may occur in a solitary activity, it emerges from interactions with others and involves socially constructed meanings, knowledge, language, and motives (Elisondo, 2017). In other words, the generation of new ideas emerges from the integration and combination of perspectives that are linked to social actions (Elisondo, 2017). Nevertheless, more research is needed to understand the mechanisms that deeply underlie this association. Despite the need for further study, the significant association found between creativity and social cognition is noteworthy, because it seems to be even greater than the relationship between creativity and neurocognition.

Regarding clinical data, the age of onset of the disease and clinical symptomatology, mainly negative symptomatology, were negatively related to creativity. Furthermore, regression analyses showed that fewer negative symptoms predicted higher creativity. The fact that patients with a lower age of onset had higher creative scores is an interesting and unexpected result. A possible explanation of this finding could be related to the decrease in creativity that occurs in adolescence

Table 2
Stepwise regressions predicting total, figural, and verbal creativity.

Criterion variable	R^2	R^2 change	B	t	p	Predictors
Total creativity	21.8%	11.5%	.286	2.948	.004	SP
		4.3%	.219	2.303	.023	PS
Figural creativity	21.8%	14.9%	.298	3.163	.002	SP
		6.9%	.277	2.943	.004	PS
Verbal creativity	20.6%	10.3%	-.302	-3.215	.002	Negative symptoms
		4.0%	.210	2.222	.029	SP

Figural creativity and verbal creativity variables are the sum of each figural and verbal dimension, respectively. Total creativity is the average of all creative scores. Negative symptoms were assessed by the Brief Negative Symptom Scale. SP = Social Perception; PS = Processing Speed.

Table 3
Stepwise regressions predicting creativity subdimensions.

Criterion variable	R^2	R^2 change	β	t	p	Predictors
Figural elaboration	27.7%	10.8%	.276	3.045	.003	PS
		4.7%	.249	2.494	.014	ToM
Figural abstractness of titles	29.6%	16.7%	.307	3.458	.001	ToM
		9.6%	.261	2.886	.005	WM
		3.4%	.198	2.159	.033	PS
Verbal originality	15.5%	11.9%	.310	3.277	.001	SP
		3.6%	-.192	-2.031	.045	Negative symptoms
Verbal flexibility	19.6%	10.2%	.275	2.888	.005	ToM
		4.1%	.211	2.227	.028	PS
Verbal fluency	16.9%	12.4%	-.362	-3.818	<.001	Negative symptoms

Negative symptoms were assessed by the Brief Negative Symptom Scale. PS = Processing Speed; ToM = Theory of Mind; WM = Working Memory; SP = Social Perception.

(Runco, 2007). Specifically, the creative expression of children entering the adolescent period usually falls dramatically due to several inhibitory mechanisms such as those related to the pressure of conventionality that occurs during Kohlberg's conventional thinking stage (Lau and Cheung, 2010; Runco, 2007). Patients who suffer from schizophrenia from an early age may probably show lower inhibitory mechanisms related to the pressure of conventionality and, therefore, may not show as much decrease in creativity compared to patients with schizophrenia with a later age of onset. Nevertheless, as this is not a longitudinal study, this interpretation should be considered with caution. The negative association between negative symptoms and creativity of people with schizophrenia is in line with results from Jaracz et al. (2012), but not with results from Abraham et al. (2007). However, none of these studies assessed negative symptoms with the instruments based on the NIMH-MATRICS Consensus Statement on Negative Symptoms (Carpenter et al., 2016; Kirkpatrick et al., 2006). Unexpectedly, negative symptoms predicted verbal fluency, but other variables such as PS or VM did not. Tasks requiring verbal abilities are specially challenging for patients with schizophrenia, and some negative symptoms such as alogia or apathy have been particularly related to difficulties in verbal fluency tasks (Docherty et al., 2011; Hartmann-Riemer et al., 2015). Furthermore, being aware of their difficulties, patients could show less motivation to perform verbal tasks, which could be reflected in their performance of the task (Foussias et al., 2014).

It should not be overlooked that, although all these factors appear to play an important role in the creativity of people with schizophrenia, the variance explained by them in the regression analyses was not very high. This may be because, as might be expected, other types of factors are also relevant when explaining creativity. For instance, intrinsic motivational procedures have shown to influence the scores obtained in a creativity task (Ceci and Kumar, 2016). Another factor that have shown to influence creativity is the exposure to diverse information, as this can activate remote associations in the mind between diverse concepts (Clapham, 2000). In addition, individuals with very diverse interests and experiences may have more unusual associations between concepts and hence, may be more creative (Clapham, 2000). Therefore, it has been suggested that individuals' personality and personal experience are other important factors explaining creativity (Puryear et al., 2017). Specifically, openness to experience and extraversion have been positively associated with creativity (Puryear et al., 2017). Nevertheless, given the complexity of this capacity, many other factors could influence creativity, so more research is needed to understand this issue.

One limitation that should be considered concerns the test employed to measure creativity. Although the Torrance Test of Creative Thinking is the most widely used measure of creativity (Kim, 2011) and has shown a high reliability (Said-Metwaly et al., 2017), this test also has several constrains, such as a lack of validity and the bias due to scoring and sample size (Baer, 2011; Said-Metwaly et al., 2017). Due to the complexity of creativity, the instruments available at the moment have limitations and are unable to measure alone this multidimensional construct (Said-Metwaly et al., 2017). Therefore, employing a single test to measure creativity may not be adequate and thus, future studies should include multiple instruments to measure this capacity (Kim, 2006). A second limitation is that, although this study included a multidimensional neurocognitive assessment, other cognitive domains also impaired in schizophrenia such as visual and auditory perception or visual memory could have provided a further understanding of the role of neurocognition in creativity in this disease. Future research could analyze the role of these domains in this relationship.

Despite these limitations, findings from this study seem relevant, since they point to the important role of some neurocognitive, social cognitive, and clinical variables in creativity. Moreover, these results indicate that social cognition is essential for creative thinking, even more than other neurocognitive domains. In addition, the importance of this study lies on the fact that creativity has been suggested to be a key factor for real-life functioning (Flood and Scharer, 2006; Plucker et al., 2015). Thus, the impaired creativity found in schizophrenia (Acar et al., 2017) could be negatively influencing daily functioning of these people. For this reason, the understanding of which domains underlie creativity is essential for the development of cognitive rehabilitation programs to improve creativity and in turn, daily life functioning and quality of life of patients with schizophrenia.

Contributors

Authors NO, NIB, JP, and PS designed the study and wrote the protocol. Authors AS, PS, NIY, MTE, IH, and CP performed the clinical and neuropsychological evaluations. AS and JP managed the literature searches and undertook the statistical analysis. AS and JP wrote the first draft of the manuscript. All authors contributed to the writing and revision of the manuscript. All authors have approved the final manuscript.

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Declaration of competing interest

All authors declare that they have no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2020.06.019.

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