BJPsych Open (2023)
9, e19, 1–6. doi: 10.1192/bjo.2022.614

Cognitive versus emotional modulation within a Stroop paradigm in patients with schizophrenia

Verónica Romero-Ferreiro†, Ana García-Gutiérrez†, Iosune Torio, Paloma Marí-Beffa, Pablo Rodríguez-Gómez, José A. Periáñez, Eva M. Moreno, Carmen Romero, Miguel Ángel Alvarez-Mon and Roberto Rodriguez-Jimenez

Background

Schizophrenia is a complex disorder involving deficits in both cognitive and emotional processes. Specifically, a marked deficit in cognitive control has been found, which seems to increase when dealing with emotional information.

Aims

With the aim of exploring the possible common links behind cognitive and emotional deficits, two versions of the emotional Stroop task were administered.

Method

In the cognitive-emotional task, participants had to name the ink colour (while ignoring the meaning) of emotional words. In contrast, the emotional-emotional task consisted of emotional words superimposed on emotional faces, and the participants had to indicate the emotional valence of the faces. Fifty-eight participants (29 in-patients diagnosed with schizophrenia and 29 controls) took part in the study.

Results

Patients and controls showed similar response times in the cognitive-emotional task; however, patients were significantly slower than controls in the emotional-emotional task. This result supports the idea that patients show a more pronounced impairment in conflict modulation with emotional content. Besides, no significant correlations between the tasks and positive or negative symptoms were found. This would indicate that deficits are relatively independent of the clinical status of patients. However, a significant correlation between the emotional-emotional task and cognitive symptoms was found.

Conclusions

These findings suggest a restricted capacity of patients with schizophrenia to deal with the attentional demands arising from emotional stimuli.

Keywords

Schizophrenia; cognitive control; conflict modulation; Stroop task; emotion.

Schizophrenia is an important psychiatric disorder characterised by different psychopathological dimensions such as positive, negative or cognitive symptoms. A key component of cognitive functions is cognitive control, which has proven to be essential for the proper execution of goal maintenance, set-shifting and inhibition.[1] Cognitive control is necessary when we block an habitual or automatic behaviour, and instead execute a less familiar/alternative behaviour.[2] It is essential for daily life and its deficit has been associated with social and behavioural disturbances.[3] Apart from deficits in neurocognition, schizophrenia usually involves impairments in emotional processing, a domain of social cognition abilities.[4–6] Particularly, the ability to understand emotional cues and integrating emotion perception with context is severely disturbed.[7,8] Facing conflicting cues is relatively common in social interactions, and can happen when, for example, someone masks their true feelings or there is sarcastic irony. These conflicting cues present an even greater challenge for patients with schizophrenia.[9] Consequences of cognitive and emotional processing deficits have been studied separately, and the possible common links behind those deficits have not been extensively described.[10,11] The search for a greater understanding of the association between executive function and emotion has motivated the use of experimental paradigms such as the emotional version of the Stroop task.[12,13] In this version, the emotional valence of the word usually slows down the identification of the ink colour, suggesting that the affective content of stimuli affects the processing of perceptual aspects of it.[14] The emotional Stroop task has been proposed as a useful task to link several abnormalities in the cognitive functioning of schizophrenia as a neuropsychological endophenotype.[15,16] It combines emotional (as distractor) and non-emotional (as required response) information (e.g. naming the ink colour of an emotional word). Only a few attempts of comparing patients with schizophrenia in a cognitive versus emotional Stroop task involving faces have been made. They have found slower response times in incongruent compared with congruent trials in both versions of the task.[17,18] However, in these studies, the cognitive task was to indicate the gender of a face with an incongruent word (the contrary gender) superimposed.

The main aim of this research is to study cognitive control understood as the capacity of patients to suppress irrelevant information in cognitive-emotional versus purely emotional versions of the emotional Stroop task. Although both versions included emotional words as distractors, the attribute required from the participant could be either emotional (i.e. the emotional valence of a face) or perceptual (i.e. the ink colour of the word). This procedure allows to study to what extent cognitive and emotional control are affected in patients with schizophrenia. As a secondary objective, the relationship between performance on both types of Stroop tasks and some clinical variables (symptoms, medication dosage and age at onset of the disorder) was examined.

† Joint first authors.

https://doi.org/10.1192/bjo.2022.614 Published online by Cambridge University Press

Method

Participants

Twenty-nine in-patients with schizophrenia were included in this study. Patients were recruited at the acute psychiatric unit of the Hospital Universitario 12 de Octubre (Madrid, Spain). They took part in this study at the time of hospital discharge, when their referring psychiatrist felt that they had a certain degree of psychopathological stability. All patients were diagnosed with schizophrenia according to DSM-5 criteria,[19] using the Structured Clinical Interview for DSM-5, Research Version.[20] All participants were on second-generation antipsychotics, except for four participants who were receiving a combination of first- and second-generation antipsychotics, and two participants who were on first-generation antipsychotics only. Additionally, 19 participants were receiving another type of psychotropic drug treatment, 16 of which were benzodiazepines. Antipsychotic treatment was converted to chlorpromazine equivalents.[21] Clinical status was evaluated with the Spanish version of the Positive and Negative Syndrome Scale (PANSS).[22,23] On that basis, the Wallwork five-factor model for the PANSS (positive, negative, cognitive/disorganised, excited and depressed), which has been validated in the Spanish population, was also calculated.[24,25] See Table 1 for sociodemographic variables and clinical status.

The inclusion criteria were as follows: diagnosis of schizophrenia disorder according to DSM-5 criteria, clinical stabilisation before discharge from the hospital unit, aged 18–55 years and sufficient fluency in Spanish to allow them to complete the protocol. Exclusion criteria for patients included the presence of electroconvulsive therapy in the previous year, neurological disorders or somatic diseases that could interfere with the performance of the tasks, any active major substance misuse/dependence (excluding caffeine and nicotine), intellectual disability (IQ<70) evaluated with the Spanish version of the Word Accentuation Test,[26] autism spectrum disorder, inability or unwillingness to participate and other major psychiatric comorbidities such as affective disorders. The comparison group was composed of 29 matched (in terms of age and gender) controls with no personal or first-degree family history of psychotic disorders.

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. All procedures were approved by the Ethics Committee of the Hospital Universitario 12 de Octubre (approval number 17/308). Written informed consent was obtained from all participants before their inclusion in the study.

Table 1 Sample demographics and clinical status of patients

	Patients (n= 29) Mean (s.d.)	Controls (n = 29) Mean (s.d.)	Statistic (P-value)
Age, years	35.9 (10.8)	37.07 (13.32)	t = 0.369 (P = 0.71)
Gender, % male	55.2%	37.9%	χ^2 = 1.73 (P = 0.18)
Years of education	10.0 (2.9)	15.36 (1.97)	t = 7.61 (P < 0.001)
Duration of illness, years	11.2 (11.3)	——	——
PANSS Positive	14.7 (3.6)	——	——
PANSS Negative	19.3 (7.0)	——	——
PANSS Disorganised	9.1 (2.8)	——	——
PANSS Excited	9.8 (3.9)	——	——
PANSS Depressed	7.7 (2.8)	——	——
CPZeq	643.0 (465.5)	——	——

The consensus five-factor Wallwork model (for the PANSS) scores were calculated. PANSS, Positive and Negative Syndrome Scale; CPZeq, chlorpromazine equivalent dose (mg/day).

Materials

The present study comprised two tasks developed within a Stroop paradigm framework. The experimental design was specifically developed for this purpose. Although both versions of the task included emotional stimuli, one of them required a response about the emotional valence of the face (which is why it is called the emotional-emotional Stroop task (EESt)), whereas the other task required perceptual aspects of the stimuli, i.e. the ink colour of an emotional word (cognitive-emotional Stroop task (CESt)).

The target facial stimuli consisted of 36 pictures taken from the NimStim stimulus set.[27] Three pictures from each model, showing happy, angry and neutral expressions, were selected. Additionally, 72 emotional words (24 positive, 24 negative and 24 neutral) were selected from two different databases.[28,29] The length of the words and frequency of use were controlled to remain constant along the three emotional categories. All words had between three and four syllables and ≥30 points in relative frequency of use per million. Stimuli were selected based on their valence and arousal values. Words with extreme valence scores (either positive or negative) were selected, ensuring that they had similar arousal values and the smallest possible s.d. The mean valence value of the final set was 7.54 (s.d. = 0.46) for positive words and 2.32 (s.d. = 0.73) for negative words ($t(46) = 41.98$, $P < 0.001$), on a scale with anchor points from 1 (very negative) to 9 (very positive). Positive and negative words did not differ in terms of arousal ($t(46) = 1.29$, $P = 0.203$; positive pictures: mean 6.06, s.d. = 0.36; negative pictures: mean 6.08, s.d. = 0.99). The arousal scale ranged from 1 (very calming) to 9 (very arousing). The neutral words had a mean valence of 4.97 (s.d. = 0.27) and mean arousal of 4.03 (s.d. = 0.39).

Procedure

The procedure was developed in E-Prime version 2.0 for Windows (PsychologySoftware Tools, Pittsburgh, USA; https://pstnet.com/products/e-prime/). For the EESt, a target face appeared with an emotional word superimposed. Participants were asked to categorise the emotional valence of the face while ignoring the word. Keyboard responses were given by tapping buttons 1, 2 or 3, corresponding to positive, neutral or negative valence. Participants were free to use their preferred hand. Figure 1 shows an example of the screen response. In this task, words were randomly divided into three groups, each one with the same number of positive, negative and neutral words. Each group was randomly paired with positive, negative and neutral faces in such a way that all of the experimental conditions had the same number of stimuli.

Then, the second block containing the cognitive version of the task (CESt) was administered. Participants were presented with a target word (the same set presented in the EESt) printed in either red, blue or green. They were asked to select the colour of the word while ignoring its meaning. As in the previous task, each category of words (positive, negative and neutral) was divided into three subsets, with an equal number of stimuli. Figure 1(b) shows a screenshot of this task. Accuracy data as well as response times were recorded for both tasks. The final number of trials for both tasks was 72. The order of blocks was counterbalanced across participants.

Data analysis

First, *a priori* sample size was calculated with G*Power for Windows (Heinrich Heine University, Düsseldorf, Germany; https://www.psychologie.hhu.de/arbeitsgruppen/allgemeine-psychologie-und-arbeitspsychologie/gpower) version 3.1. We wanted to be able to

https://doi.org/10.1192/bjo.2022.614 Published online by Cambridge University Press

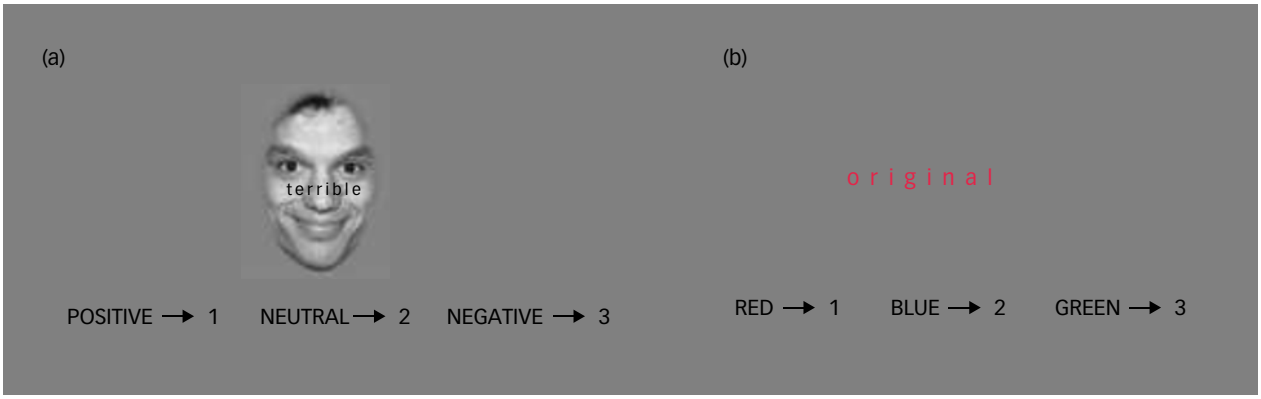

Fig. 1 (a) Example of a trial of the EESt. Participants had to respond to the emotional valence of the face, ignoring the word. (b) Example of a trial of the CESt. Participants had to respond to the ink colour of the word, ignoring its meaning. CESt, cognitive-emotional Stroop task; EESt, emotional-emotional Stroop task.

detect a relatively small effect size of $\eta^2_p = 0.4$, using an alpha level of 0.05. The total sample size resulted in 54 participants, which would give a statistical power of 80%. Altogether, we included 58 participants.

Data were managed and analysed with IBM SPSS for Windows (IBM Corporation, Chicago, USA; https://www.ibm.com/spss) version 24. Simple comparisons (χ^2-test for gender distribution and *t*-tests for age and years of education) between patients and controls were used for sociodemographic variables.

Regarding analysis of response times, we first removed the error trials before performing the computing analysis. Then, positive and negative interference scores were calculated. Interference is, by definition, a difference score between a baseline or non-conflicting measure (in this case, those trials in which the word was neutral) and a conflict condition (e.g. a trial in which the face was happy and the word was negative). Consequently, the negative interference score was calculated by subtracting the average response time of trials where the distractor was a neutral word, from negative incongruent trials. The same procedure was followed for calculating the positive interference score. Once interference effect was calculated for each condition, a $2 \times 2 \times 2$ repeated-measures analysis of variance was conducted. The task (EESt, CESt) and the interference (positive, negative) were the within-participant factors, whereas the group (patients, controls) was the between-participants factor. Greenhouse–Geisser and Bonferroni corrections were applied when appropriate. Finally, Pearson's correlations were conducted to explore the possible association of performance in both tasks with clinical symptoms (PANSS factors according to the Wallwork model) and antipsychotic medication dosage (chlorpromazine equivalents). Results were considered significant when $P < 0.05$.

Results

As Table 1 shows, patients did not differ from controls in terms of age ($t(56) = 0.369$, $P = 0.71$) or gender distribution ($\chi^2 = 1.73$, $P = 0.18$). Patients had significantly fewer years of education compared with healthy controls ($t(51) = 7.61$, $P < 0.001$). Mean response times and error rates for each of the conditions in the task are presented in Table 2.

Interference effect (response times)

Here, both tasks were submitted to the same analysis. First, a main effect of group was found ($F(1,40) = 9.44$, $P = 0.004$, $\eta^2_p = 0.19$). Patients showed higher interference than controls (patients: mean 393.33, s.d. = 425.37; controls: mean 90.72, s.d. = 317.08; 95% CI 103.51–501.73). Second, a task×group interaction was found ($F(1,40) = 12.18$, $P = 0.001$, $\eta^2_p = 0.23$). Although there were no significant differences between patients and controls in the CESt ($P = 0.831$), the interference in the EESt was higher for patients than for controls (patients: mean 744.19, s.d. = 738.36; controls: mean 152.39, s.d. = 550.31; $P = 0.001$, 95% CI 246.20–937.42). Additionally, an interference×group interaction was also present ($F(1,40) = 7.705$, $P = 0.008$, $\eta^2_p = 0.16$). Regarding negative interference, there were no differences between patients and controls ($P = 0.418$). However, patients with schizophrenia showed higher interference effects than controls in positive incongruent trials (patients: mean 649.63, s.d. = 563.07; controls: mean 139.77, s.d. = 419.67; $P < 0.001$, 95% CI 246.30–773.43). Finally, the triple interaction task×interference×group was marginally significant ($F(1,40) = 2.91$, $P = 0.096$, $\eta^2_p = 0.07$) (see Fig. 2). Similarly, *post hoc* comparisons revealed that in the EESt, patients showed greater positive interference than controls (patients: mean 1189.92, s.d. = 1016.4; controls: mean 269.11, s.d. = 757.6; $P < 0.001$, 95% CI 445.04–1396.58).

Cross-task and clinical variables correlations

The correlation between clinical variables and positive and negative interference in both the EESt and CESt are shown in Table 3. As can

Table 2 Mean response times (milliseconds) and error rates for each group and experimental condition of each task

		Mean response time (s.d.)		Mean error rate (s.d.)	
		Patients	Controls	Patients	Controls
Cognitive-emotional Stroop task	Neutral word	1699.71 (717.13)	843.88 (249.07)	0.09 (0.16)	0.015 (0.03)
	Positive word	1701.09 (630.64)	807.17 (206.95)	0.09 (0.17)	0.015 (0.03)
	Negative word	1815.36 (722.74)	813.20 (221.02)	0.09 (0.17)	0.014 (0.03)
Emotional-emotional Stroop task	Neutral distractor	2697.85 (1140.65)	1459.99 (1120.22)	0.21 (0.17)	0.014 (0.14)
	Positive distractor	3130.58 (1191.19)	1226.11 (295.58)	0.29 (0.25)	0.015 (0.23)
	Negative distractor	4147.58 (1842.39)	1553.78 (822.39)	0.43 (0.30)	0.013 (0.19)

https://doi.org/10.1192/bjo.2022.614 Published online by Cambridge University Press

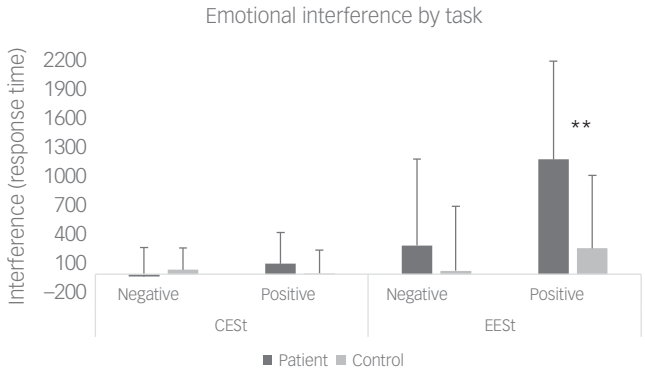

Fig. 2 Interference effect separated by affective valence of distractor words and task. Error bars denote s.d. CESt, cognitive-emotional Stroop task; EESt, emotional-emotional Stroop task. $^{**}P < 0.001$.

be seen, no significant correlations were found between tasks and symptoms, medication dose or age at onset of the disorder, except for the EESt negative interference condition and the cognitive/disorganised factor of the Wallwork model ($r = 0.46$, $P = 0.04$).

Discussion

The main objective of this study was to compare a group of patients with schizophrenia with a healthy control group in a cognitive versus emotional conflict modulation task. For this purpose, two emotional versions based on the Stroop paradigm were designed. In general terms, results reported in this study support the idea that patients with schizophrenia show a more pronounced deficit in emotional as opposed to cognitive control, compared with a group of healthy controls. Specifically, that deficit appears to be slanted toward positive emotional stimuli.

Interference measures based on response times suggested a poorer capacity of patients to inhibit irrelevant emotional information in the emotional conflict task compared with that of healthy controls. This outcome supports the notion that emotional information selectively interferes with the processing of emotional aspects of the target stimuli to a high degree in patients with schizophrenia. Analogous to the current cognitive task, previous literature found overall slower response times for patients with schizophrenia compared with controls.[30,31] Nevertheless, our results give additional evidence in the context of a within-task comparison, in which differences between patients and controls in the cognitive task appear to be smaller than those found in the emotional task. One possible explanation for the longer response times in patients with schizophrenia might be related to proactive versus reactive modes of cognitive control. Proactive control relies on the anticipation and prevention of interference before it occurs, whereas reactive control is considered a 'late correction' mechanism that is mobilised when a high-interference event is detected.[32] Thus, the reactive form of control is less effective. Some authors have suggested that proactive control may be particularly impaired schizophrenia.[33] This would lead individuals with schizophrenia to rely more heavily on reactive control, especially when emotion-related conflicting information is handled.

Of special interest is the greater interference effect in the emotional task when the emotional valence of the word was positive found in the group of patients with schizophrenia. One possible explanation is that identifying the target emotion of the face itself was more difficult for patients in this experimental condition compared with identifying the expression of a neutral or a happy face in the negative interference condition. This could be a plausible explanation considering that the most frequently found pattern in literature is a preserved recognition of positive expressions and an impaired recognition of negative emotions.[34,35] Nevertheless, this effect should be treated with caution as the triple interaction was only marginally significant. Further studies are necessary to confirm this preliminary outcome.

Table 3 Pearson's correlations [95% confidence intervals] between interference in the cognitive-emotional Stroop task and emotional-emotional Stroop task, age at onset of disorder, chlorpromazine equivalent dose and the consensus five-factor Wallwork model (for the PANSS) scores, for patients diagnosed with schizophrenia

	Emotional-emotional Stroop task		Cognitive-emotional Stroop task	
	Positive interference	Negative interference	Positive interference	Negative interference
Age at onset (mean 24.9, s.d. = 9.2)	$r = 0.06$ [−0.44 to 0.52] $P = 0.831$	$r = -0.31$ [−0.67 to 0.17] $P = 0.203$	$r = 0.30$ [−0.12 to 0.63] $P = 0.155$	$r = 0.33$ [−0.07 to 0.64] $P = 0.104$
CPZeq (mean 643.0, s.d. = 465.5)	$r = -0.17$ [−0.59 to 0.32] $P = 0.493$	$r = -0.10$ [−0.52 to 0.36] $P = 0.663$	$r = 0.13$ [−0.27 to 0.49] $P = 0.528$	$r = -0.07$ [−0.44 to 0.32] $P = 0.716$
PANSS Positive (mean 14.7, s.d. = 3.6)	$r = 0.25$ [−0.24 to 0.45] $P = 0.315$	$r = 0.29$ [−0.17 to 0.65] $P = 0.215$	$r = 0.02$ [−0.37 to 0.40] $P = 0.932$	$r = 0.08$ [−0.31 to 0.40] $P = 0.691$
PANSS Negative (mean 19.3, s.d. = 7.0)	$r = -0.08$ [−0.53 to 0.49] $P = 0.745$	$r = 0.12$ [−0.34 to 0.53] $P = 0.624$	$r = 0.13$ [−0.27 to 0.49] $P = 0.520$	$r = 0.13$ [−0.26 to 0.49] $P = 0.517$
PANSS Cognitive (mean 9.1, s.d. = 2.8)	$r = 0.03$ [−0.44 to 0.33] $P = 0.910$	**$r = 0.46$ [0.03 to 0.75] $P = 0.04$***	$r = 0.16$ [−0.24 to 0.51] $P = 0.442$	$r = -0.06$ [−0.43 to 0.51] $P = 0.779$
PANSS Excited (mean 9.8, s.d. = 3.9)	$r = 0.12$ [−0.37 to 0.37] $P = 0.642$	$r = 0.28$ [−0.19 to 0.64] $P = 0.239$	$r = -0.03$ [−0.41 to 0.36] $P = .893$	$r = -0.01$ [−0.39 to 0.36] $P = 0.945$
PANSS Depressed (mean 7.7, s.d. = 2.8)	$r = 0.16$ [−0.33 to 0.64] $P = 0.528$	$r = -0.05$ [−0.48 to 0.40] $P = 0.835$	$r = -0.10$ [−0.47 to 0.30] $P = 0.619$	$r = -0.35$ [−0.04 to 0.30] $P = 0.074$

CPZeq, chlorpromazine equivalent dose (mg/day); PANSS, Positive and Negative Syndrome Scale.
*$P < 0.05$; significant correlations are highlighted in bold.

https://doi.org/10.1192/bjo.2022.614 Published online by Cambridge University Press

As a secondary objective, the relationship between performance of patients in both tasks and some clinical variables was studied. In this regard, no significant correlations with positive or negative PANSS factors, antipsychotic dosage or age at onset of disorder were found. Such results can be interpreted as a deficit, which is present in patients with schizophrenia regardless of the classic symptom course. The absence of a correlation with negative symptoms could be striking, given the frequent overlapping between negative and cognitive symptoms and the link with neurobiological impairments such as the limbic system,[36] or even inflammatory conditions.[37] Nevertheless, other authors have also found cognitive deficits to be independent of positive and negative symptoms in schizophrenia.[38] Despite this, a positive correlation between the negative interference in the emotional version of the Stroop task and the cognitive/disorganised PANSS factor was found. This finding makes sense, considering that this factor of the PANSS evaluates clinically cognitive impairments in a broader sense.[25] Some previous studies have found a relationship between cognitive/disorganised symptoms and a variety of tasks evaluating inhibitory control in schizophrenia.[39,40] It is possible that because threatening information has the greatest capacity to capture attention,[41] this could explain the correlation between the cognitive/disorganised PANSS factor and the specific condition of negative interference. In this sense, those patients with symptoms of disorganisation would find it harder to redirect attention to the target compared with patients with other clinical profiles or control participants. From the clinical point of view, this result highlights the importance of cognitive control as a useful target for intervention regardless of the predominant symptoms in schizophrenia. In this regard, some results indicate that cognitive remediations aimed to increase response inhibition or executive function also had an impact on functional ability.[42] It remains to be seen whether specific training of emotion-related conflict has an impact on ability to understand emotional cues in schizophrenia.

The main strength of this study is the between-group experimental design, in which patients with schizophrenia and healthy controls were compared across two versions of the emotional Stroop task. The experimental design is rigorous, considering that the stimuli was selected from normative studies and matched in terms of arousal. Nevertheless, our study has some limitations. First, the sample included in-patients at discharge, and results may not be entirely generalisable to out-patients with schizophrenia. Also, generalisation of our results should be taken with caution, as patients with schizophrenia often have other major psychiatric comorbidities, but it was considered an exclusion criterion of our sample. Second, this paradigm creates a highly artificial situation not easily comparable with real-life situations. Finally, a more detailed clinical, as well as cognitive, characterisation of the patient sample would have been desirable.

In conclusion, patients with schizophrenia showed a decreased ability to inhibit the emotional valence of words, especially when competing information shared emotional content. These results help to provide a better understanding of the altered cognitive and emotional mechanisms in schizophrenia, and will be of value in the development of future cognitive rehabilitation programmes.

Verónica Romero-Ferreiro, Department of Psychology, Universidad Europea de Madrid, Spain; Department of Psychiatry, Instituto de Investigación Hospital 12 de Octubre (Imas12), Spain; and Biomedical Research Networking Centre for Mental Health/Carlos III Health Institute (CIBERSAM/ISCIII), Spain; **Ana García-Gutiérrez**, Department of Experimental Psychology, Cognitive Psychology and Speech & Language Therapy, Complutense University of Madrid, Spain; **Iosune Torio**, Department of Psychiatry, Hospital Universitario de La Princesa, Spain; **Paloma Marí-Beffa**, School of Psychology, Bangor University, Wales, UK; **Pablo Rodríguez-Gómez**, Department of Psychology, Faculty of Health Sciences, Universidad Rey Juan Carlos, Spain; **José A. Periáñez**, Department of Experimental Psychology, Cognitive Psychology and Speech & Language Therapy, Complutense University of Madrid, Spain; **Eva M. Moreno**, Biomedical Research Networking Centre for Mental Health/Carlos III Health Institute (CIBERSAM/ISCIII), Spain; Pluridisciplinar Institute, Complutense University of Madrid, Spain; and Department of Languages and Education, Universidad de Nebrija, Spain; **Carmen Romero**, Scientific Support Unit, Instituto de Investigación Hospital 12 de Octubre (Imas12), Spain; Biomedical Research Networking Centre for Epidemiology and Public Health/Carlos III Health Institute (CIBERESP/ISCIII), Spain; and Faculty of Health Sciences, Universidad Francisco de Vitoria, Spain; **Miguel Ángel Alvarez-Mon**, Department of Medicine and Medical Specialities, Faculty of Medicine and Health Sciences, University of Alcalá, Spain; Department of Psychiatry and Mental Health, Hospital Universitario Infanta Leonor, Spain; Ramón y Cajal Institute of Sanitary Research (IRYCIS), Spain; **Roberto Rodriguez-Jimenez**, Department of Psychiatry, Instituto de Investigación Hospital 12 de Octubre (Imas12), Spain; Legal Medicine, Psychiatry and Pathology, Biomedical Research Networking Centre for Mental Health/Carlos III Health Institute (CIBERSAM/ISCIII), Spain; and Legal Medicine, Psychiatry and Pathology, Complutense University of Madrid, Spain

Correspondence: Verónica Romero-Ferreiro.
Email: veronica.romero@universidadeuropea.es

First received 25 Mar 2022, final revision 2 Nov 2022, accepted 4 Nov 2022

Data availability

The data that support the findings of this study are available from the corresponding author, V.R.-F., upon reasonable request.

Author contributions

V.R.-F., A.G.-G. and R.R.-J. designed the study. A.G.-G., P.M.-B. and J.A.P. outlined the methodology. V.R.-F., P.R.-G. and C.R. undertook the statistical analysis. V.R.-F., A.G.-G., I.T., M.A.A.-M. collected data. V.R.-F., A.G.-G., I.T. and R.R.-J. wrote the first draft of the manuscript. P.M.-B., E.M.M. and R.R.-J. substantially reviewed the manuscript. All authors have read and approved the submitted version, and agree to account for their own contributions and the accuracy or integrity of any part of the work.

Funding

This work was supported in part by the Spanish Ministerio de Ciencia, Innovación y Universidades (grant number PSI2018-098876-B-100) to E.M.M., and in part by the Instituto de Salud Carlos III (grant numbers PI16/00359 and PI19/00766; Fondo de Investigaciones Sanitarias/FEDER), the European Development Regional Fund 'A way to achieve Europe' (ERDF), the Madrid Regional Government (R&D Activities in Biomedicine S2017/BMD-3740 (AGES-CM 2-CM)) and Structural Funds of the European Union.

Declaration of interest

R.R.-J. has been a consultant for, spoken in activities of, or received grants from the Instituto de Salud Carlos III, Fondo de Investigación Sanitaria (FIS), Centro de Investigación Biomédica en Red de Salud Mental (CIBERSAM), Madrid Regional Government (S2010/BMD-2422 AGES; S2017/BMD-3740), Janssen-Cilag, Lundbeck, Otsuka, Pfizer, Ferrer, Juste, Takeda, Exeltis, Angelini, Casen-Recordati and Rovi. The other authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

1 Botvinick MM, Carter CS, Braver TS, Barch DM, Cohen JD. Conflict monitoring and cognitive control. *Psychol Rev* 2001; **108**(3): 624–52.

2 Matsumoto K, Tanaka K. Conflict and cognitive control. *Science* 2004; **303**: 969–70.

3 Larson MJ, South M, Clayson PE, Clawson A. Cognitive control and conflict adaptation in youth with high-functioning autism. *J Child Psychol Psychiatry Allied Discip* 2012; **53**(4): 440–8.

4 Green MJ, Waldron JH, Coltheart M. Emotional context processing is impaired in schizophrenia. *Cogn Neuropsychiatry* 2007; **12**(3): 259–80.

5 Morris RW, Weickert CS, Loughland CM. Emotional face processing in schizophrenia. *Curr Opin Psychiatry* 2009; **22**(2): 140–6.

6 Patrick RE, Rastogi A, Christensen BK. Effortful versus automatic emotional processing in schizophrenia: insights from a face-vignette task. *Cogn Emot* 2015; **29**(5): 767–83.

7 Kring AM, Elis O. Emotion deficits in people with schizophrenia. *Annu Rev Clin Psychol* 2013; **9**: 409–33.

8 Romero-Ferreiro V, Aguado L, Torío I, Sánchez-Morla EM, Caballero-González M, Rodriguez-Jimenez R. Influence of emotional contexts on facial emotion attribution in schizophrenia. *Psychiatry Res* 2018; **270**: 554–9.

9 Mitchell RLC, Rossell SL. Perception of emotion-related conflict in human communications: what are the effects of schizophrenia? *Psychiatry Res* 2014; **220** (1–2): 135–44.

https://doi.org/10.1192/bjo.2022.614 Published online by Cambridge University Press

10 Anticevic A, Corlett PR. Cognition-emotion dysinteraction in schizophrenia. *Front Psychol* 2012; **3**: 392.

11 Ferrer-Quintero M, Fernández D, López-Carrilero R, Birulés I, Barajas A, Lorente-Rovira E, et al. Persons with first episode psychosis have distinct profiles of social cognition and metacognition. *NPJ Schizophr* 2021; **7**(1): 61.

12 Stroop JR. Studies of interference in serial verbal reactions. *Jorunal Exp Psychol* 1935; **18**(6): 643–62.

13 Williams JMG, Mathews A, MacLeod C. The emotional Stroop task and psychopathology. *Psychol Bull* 1996; **122**(1): 3–24.

14 Burt JS. Why do non-color words interfere with color naming? *J Exp Psychol Hum Percept Perform* 2002; **28**(5): 1019–38.

15 Aleksandrowicz A, Hagenmuller F, Haker H, Heekeren K, Theodoridou A, Walitza S, et al. Frontal brain activity in individuals at risk for schizophrenic psychosis and bipolar disorder during the emotional Stroop task – an fNIRS study. *NeuroImage Clin* 2020; **26**(2015): 102232.

16 Feroz FS, Leicht G, Rauh J, Mulert C. The time course of dorsal and rostral-ventral anterior cingulate cortex activity in the emotional Stroop experiment reveals valence and arousal aberrant modulation in patients with schizophrenia. *Brain Topogr* 2019; **32**(1): 161–77.

17 Egner T, Etkin A, Gale S, Hirsch J. Dissociable neural systems resolve conflict from emotional versus nonemotional distracters. *Cereb Cortex* 2008; **18**(6): 1475–84.

18 Hurtado MM, Triviño M, Panadero MA, Arnedo M, Tudela P. Comparing adaptation in emotional and non-emotional conflict in patients with schizophrenia and borderline personality disorder. *Neuropsychologia* 2018; **117**: 558–65.

19 American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders (DSM-5®)*. American Psychiatric Association, 2013.

20 First M, Williams JMG, Karg R, Spitzer R. *Structured Clinical Interview for DSM-5 Disorders–Research Version (SCID-5-RV)*. American Psychiatric Association, 2015.

21 Leucht S, Samara M, Heres S, Davis JM. Dose equivalents for antipsychotic drugs: the DDD method. *Schizophr Bull* 2016; **42**(1): S90–4.

22 Kay SR, Fiszbein A, Opfer LA. The Positive and Negative Syndrome Scale (PANSS) for schizophrenia. *Schizophr Bull* 1987; **13**(2): 261–76.

23 Peralta V, Cuesta MJ. Validation of Positive and Negative Symptom Scale (PANSS) in a sample of Spanish schizophrenic patients. *Actas Luso Esp Neurol Psiquiatr Cienc Afines* 1994; **22**(4): 171–7.

24 Wallwork RS, Fortgang R, Hashimoto R, Weinberger DR, Dickinson D. Searching for a consensus five-factor model of the Positive and Negative Syndrome Scale for schizophrenia. *Schizophr Res* 2012; **137**(1–3): 246–50.

25 Rodriguez-Jimenez R, Bagney A, Mezquita L, Martinez-Gras I, Sanchez-Morla EM, Mesa N, et al. Cognition and the five-factor model of the Positive and Negative Syndrome Scale in schizophrenia. *Schizophr Res* 2013; **143**(1): 77–83.

26 Gomar JJ, Ortiz-Gil J, McKenna PJ, Salvador R, Sans-Sansa B, Sarró S, et al. Validation of the word accentuation test (TAP) as a means of estimating premorbid IQ in Spanish speakers. *Schizophr Res* 2011; **128**(1–3): 175–6.

27 Tottenham N, Tanaka JW, Leon AC, Mccarry T, Nurse M, Hare TA, et al. The NimStim set of facial expressions: judgments from untrained research participants. *Psychiatry Res* 2009; **168**(3): 242–9.

28 Hinojosa JA, Martínez-García N, Villalba-García C, Fernández-Folgueiras U, Sánchez-Carmona A, Pozo MA, et al. Affective norms of 875 Spanish words for five discrete emotional categories and two emotional dimensions. *Behav Res Methods* 2016; **48**(1): 272–84.

29 Redondo J, Fraga I, Padrón I, Comesaña M. The Spanish adaptation of ANEW (affective norms for English words). *Behav Res Methods* 2007; **39**(3): 600–5.

30 Demily C, Attala N, Fouldrin G, Czernecki V, Ménard J-F, Lamy S, et al. The emotional Stroop task: a comparison between schizophrenic subjects and controls. *Eur Psychiatry* 2010; **25**(2): 75–9.

31 Sollier-Guillery M, Fortier A, Dondaine T, Batail JM, Robert G, Drapier D, et al. Emotions and cognitive control: a comparison of bipolar disorder and schizophrenia. *J Affect Disord Reports* 2021; **6**: 100251.

32 Barch DM, Ceaser A. Cognition in schizophrenia: core psychological and neural mechanisms. *Trends Cogn Sci* 2012; **16**(1): 27–34.

33 Edwards BG, Barch DM, Braver TS. Improving prefrontal cortex function in schizophrenia through focused training of cognitive control. *Front Hum Neurosci* 2010; **4**: 32.

34 Kohler CG, Turner TH, Bilker WB, Brensinger CM, Siegel SJ, Kanes SJ, et al. Facial emotion recognition in schizophrenia: intensity effects and error pattern. *Am J Psychiatry* 2003; **160**(10): 1768–74.

35 Romero-Ferreiro V, Aguado L, Rodriguez-Torresano J, Palomo T, Rodriguez-Jimenez R. Patterns of emotion attribution are affected in patients with schizophrenia. *Span J Psychol* 2015; **18**(1): E59.

36 Fernandez-Egea E, Parellada E, Sugranyes G, Horga G, Lomeña F, Falcon C, et al. Left amygdalar activation in deficit syndrome compared with non-deficit subjects with schizophrenia during the control task in a facial emotion recognition paradigm. *Psychiatry Res Neuroimaging* 2012; **203**: 109–10.

37 Goldsmith DR, Rapaport MH. Inflammation and negative symptoms of schizophrenia: implications for reward processing and motivational deficits. *Front Psychiatry* 2020; **11**: 46.

38 Heaton RK, Gladsjo JA, Palmer BW, Kuck J, Marcotte TD, Jeste DV. Stability and course of neuropsychological deficits in schizophrenia. *Arch Gen Psychiatry* 2001; **58**(1): 24–32.

39 Ngan ETC, Liddle PF. Reaction time, symptom profiles and course of illness in schizophrenia. *Schizophr Res* 2000; **46**(2–3): 195–201.

40 Moritz S, Andresen B, Jacobsen D, Mersmann K, Wilke U, Lambert M, et al. Neuropsychological correlates of schizophrenic syndromes in patients treated with atypical neuroleptics. *Eur Psychiatry* 2001; **16**(6): 354–61.

41 Bar-Haim Y, Lamy D, Pergamin L, Bakermans-Kranenburg MJ, Van Ijzendoorn MH. Threat-related attentional bias in anxious and nonanxious individuals: a meta-analytic study. *Psychol Bull* 2007; **133**: 1–24.

42 Tan S, Zhu X, Fan H, Tan Y, Yang F, Wang Z, et al. Who will benefit from computerized cognitive remediation therapy? Evidence from a multisite randomized controlled study in schizophrenia. *Psychol Med* 2020; **50**(10): 1633–4.

https://doi.org/10.1192/bjo.2022.614 Published online by Cambridge University Press