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REVISION

Implicit attentional bias for facial emotion in dissociative seizures: additional evidence

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Abstract

This study sought to extend knowledge about the previously reported preconscious attentional bias for facial emotion in patients with dissociative seizures (DS) by exploring whether the finding could be replicated, whilst controlling for concurrent anxiety, depression and potentially relevant cognitive impairments. Patients diagnosed with DS (n = 38) were compared to healthy controls (n = 43) on a pictorial emotional Stroop test, in which backwardly-masked emotional faces (angry, happy, neutral) were processed implicitly. The DS group displayed a significantly greater attentional bias to facial emotion relative to controls; however, the bias was not specific to negative or positive emotions. The group effect could not be explained by performance on standardised cognitive tests or self-reported depression/anxiety. The study provides additional evidence of a disproportionate and automatic allocation of attention to facial affect in patients with DS, including both positive and negative facial expressions. Such a tendency could act as a predisposing factor for developing DS initially, or may contribute to triggering individuals' seizures on an ongoing basis. Psychological interventions such as CBT or attentional bias modification might be suitable approaches to targeting this bias in clinical practice.

Key words: attentional bias, dissociative seizures, emotion, psychogenic non-epileptic seizures, conversion disorder, functional neurological disorder

I. Introduction

Dissociative seizures (DS) are also known as psychogenic, non-epileptic, or conversion seizures, and are classified as dissociative [1] and functional neurological symptom [2] disorders in ICD-10 and DSM-5 respectively. The estimated prevalence of the disorder is approximately 2-33 per 100,000 [3]. Diagnosis is typically made in early adulthood, although the disorder occurs across the lifespan [4-6]. Females are known to be over-represented [7]. Symptoms of DS differ considerably from case to case, but the events often superficially resemble epileptic seizures (ES), including pronounced alterations in awareness, sensation/perception and volition. DS are diagnosed on the basis of exclusion of clear organic causation (e.g. epilepsy, syncope, transient ischaemic attacks, hypoglycaemia), with the diagnostic 'gold standard' being a video-recorded typical seizure in the absence of associated epileptogenic abnormalities in EEG output (video-EEG) [8].

Patients with DS generally report a lack of voluntary control over seizure occurrence, with many being unable to identify specific and consistent environmental or internal antecedents to the attacks [9,10]. Nonetheless, stress is known to be a common precipitant [11]. Abnormal responses to emotional distress or bodily arousal have been hypothesised to contribute to DS occurrence, in at least a proportion of cases [12-14]. Affective manifestations and dissociative experiences during seizures are reported frequently [15-17], alongside more general elevations in psychological and somatoform dissociation [13,17-20]. Trauma, abuse, stress and family dysfunction are common risk factors [17,21-24].

Heightened scores on measures of a range of affect-related variables have been observed commonly in this group, including alexithymia [25-28], emotional dysregulation [17,28-33], anxiety [15,17,25,27,28,34,35], and depression [17,19,25,27,28,34,36]. Additionally, a limited number of experimental studies have indicated abnormalities in emotional processing in patients with DS, most commonly in responses to facial affect. Findings include impaired switching from a facial emotion categorisation task [31], exaggerated interference by facial emotion on working memory performance [37], and reduced explicit recognition and attenuated autonomic responses to facial expressions relative to controls [38]. The first experimental study of this nature [39] reported an increased attentional bias towards angry faces in patients with DS ($n = 19$) compared to healthy controls ($n = 20$) ($p < .05$), on an emotional Stroop test involving preconscious processing of affectively valenced facial stimuli.

This attentional bias correlated positively with patients' reports of sexual abuse ($p < .05$) and basal cortisol levels ($p < .05$) [39,40]. This was an important finding, as implicit attentional biases towards affective stimuli, particularly those of a negative or distressing nature, could increase overall levels of emotional arousal and distress in this patient group. Nevertheless, this possible implicit attentional bias requires further investigation and replication, before being incorporated into theoretical models and/or clinical interventions for DS.

An issue to consider when interpreting studies of this nature in this population, is the extent to which the observed attentional bias is specific to this disorder, or whether it is related to the other comorbid psychological symptoms (e.g., anxiety and depression), commonly observed in this group. There is a good evidence base to indicate, for example, that people with symptoms of anxiety show increased allocation of attention to threat-related stimuli [41,42] and individuals with depression display altered attentional allocation to negatively-valenced stimuli [43]; thus, controlling for or exploring the influence of these symptoms would facilitate interpretation of findings in this area. Furthermore, patients with DS often exhibit subtle neurocognitive abnormalities [27,30,44]; therefore, it is also necessary to account for general intellectual functioning and cognitive abilities relevant to task performance (e.g., facial perception).

The current study aimed to replicate and extend Bakvis et al.'s findings [39] by examining implicit (preconscious) facial emotion processing in a larger sample of patients with DS, and to examine the influence of anxiety, depression and relevant cognitive abilities. The DS group included in the current study had also completed a test of explicit (conscious) facial expression recognition, in which reduced emotion recognition and autonomic responses has been observed [38]. In the present experiment, behavioural performance on a pictorial emotional Stroop test was compared between the DS group and healthy controls. Anxiety and depression were measured with a validated self-report measure, and relevant cognitive abilities were assessed with standardised neuropsychological tests. It was predicted that patients with DS would display greater implicit attentional bias for facial emotion compared to the control group, and that this bias would not be explained by diminished cognitive performance or elevated anxiety and depression. It was expected that the attentional bias would be most pronounced for angry facial expressions.

2. Method

The study received ethical approval from the Joint South London and Maudsley and Institute of Psychiatry NHS Research Ethics Committee (reference 08/H0807/82). Participants provided written informed consent prior to taking part. The study was part of a larger investigation of emotional processes in patients with DS, in which patients completed several other tasks, self-report measures and cognitive assessments.

2.1. Participants

Patients with DS were recruited from two specialist neuropsychiatry clinics at the South London and Maudsley NHS Foundation Trust, UK. Diagnosis was determined on the basis of video-EEG, or consensus opinion of two neurologists, or a neurologist and a neuropsychiatrist. Control participants were recruited through websites and the distribution of fliers in the local community. All participants were between 18 and 65 years old, English-speakers, and had no documented evidence of intellectual disability.

Participants with documented diagnoses of current major depression, anxiety, substance dependence, psychosis, or major neurological disorder (including epilepsy, suspected or confirmed) were excluded from both groups. The assessment of the presence of these diagnoses in the DS sample was based on medical records, neuropsychiatric assessment (JM or other consultant neuropsychiatrist), or referral documentation from other clinicians (e.g., epileptologists). The presence of these diagnoses in healthy controls was based on self-report. Patients with DS were recruited prior to having commenced psychological treatment for DS.

2.2. Emotional Stroop task

The facial stimuli were pictures of models displaying angry, happy and neutral facial expressions from the 'Pictures of Facial Affect' [45]. The faces were cropped digitally, and coloured in a transparent shade of red, yellow or green, allowing the facial expressions and features to remain clearly visible. The faces were backwardly masked by neutral patterns, consisting of several high-contrast concentric ovals in red, green or yellow, presented on a black background. Examples of the stimuli can be found in Supplementary File 1. There were 30 facial stimuli in total, comprising 10 examples each of happy, angry and neutral

expressions. All 30 of the facial stimuli were presented three times within the experiment, each presented once in red, yellow, and green, yielding a total of 90 experimental trials. The 90 trials were presented in a different pseudo-randomised order for each participant, with no more than two stimuli of the same colour or expression presented consecutively.

The task began with nine practice trials. These consisted of a 750 millisecond (msec) presentation of a fixation cross, directly followed by a neutral pattern stimulus. Participants were requested to say aloud the colour in which the pattern was displayed as quickly as possible, with response onset registered with a voice key device. On registration of the verbal response, the pattern disappeared. The inter-stimulus interval (ISI) was fixed at two seconds, during which the screen was blank.

The experimental trials were identical to the practice trials, with the addition of individual facial stimuli presented for 17 msec, immediately after the fixation cross and prior to the masking (pattern) stimuli. This was the quickest refresh rate of the integrated laptop monitor used in the experiment; therefore, this was the minimum possible presentation time for the facial stimuli. Previous research has suggested that this is within the range (1-33 msec) that typically precludes conscious awareness of stimuli [46,47]. The face and masking stimuli on each trial were presented in the same colour. Participants were required to name aloud the colour of the masking stimulus as quickly as possible. The ISI varied between 2-4 seconds.

2.3. Awareness check

An objective awareness check was carried out after participants had completed the experimental task. The task involved a forced-choice procedure of 30 trials (identical to the experimental trials), in which participants were explicitly required to select which facial expression had been shown on each trial, from three choices (happiness, anger, neutral).

2.4. Cognitive measures

The two subscale version of the Wechsler Abbreviated Scale of Intelligence (WASI) [48] was used to assess general intellectual functioning. A standard version of the Stroop test [49] was administered to assess basic executive functioning (response

inhibition/attention/processing speed). Furthermore, the Benton Facial Recognition Test [50] measured basic perceptual processing of facial stimuli.

2.5. Self-reported psychological symptoms

The Hospital Anxiety and Depression Scale (HADS) [51] measured self-reported current (non-somatic) symptoms of anxiety and depression. Scores range from 0-21, with values of 8-10 representing borderline depression and anxiety, and scores of 11 or over being indicative of clinical levels of depression or anxiety on the respective subscales.

2.6. Data analysis

Data analysis was carried out in SPSS (v22). Between group comparisons of participant characteristics and performance on the cognitive tests were assessed with t-tests, Mann-Whitney or chi-squared tests.

For the awareness check, a mixed factorial Analysis of Covariance (ANCOVA) was used to examine the effect of group (between-subjects; DS, control) and facial expression (within-subjects; happiness, anger, neutral) on percentage correct scores. Binomial tests were used to determine whether the percentage correct scores were significantly different from chance performance.

Colour-naming errors, absolute reaction times (RTs) and attentional bias (AB) scores on the emotional Stroop test were analysed with mixed factorial ANCOVAs, with years of education (YoE) and HADS Depression and Anxiety scores included as covariates. Cognitive test scores were not included as covariates due to no group differences being observed on these measures.

Reaction time data cleaning followed the procedures described by Bakvis et al. [39], for consistency. AB scores were calculated by subtracting the mean RT for the neutral condition from the mean RT for each expression (happy or angry). For AB scores, the within-subjects factor had just two levels (expression: anger, happiness). Post-hoc tests

were conducted when appropriate, with an alpha level of $p < .01$ applied to test for significance.

Possible relationships between experimental dependent variables and patient characteristics were also examined in the DS group, including seizure frequency and duration of DS disorder. These were investigated using two-tailed Pearson's or Spearman's correlations and a stringent alpha level of $p < .01$ was adopted for significance testing, due to multiple testing.

3. Results

3.1. Participant characteristics

Table 1 provides details of participants' characteristics. There were no between-group differences in age, gender, or handedness. There was an almost significant between-groups difference in YoE. The clinical group demonstrated significantly higher Anxiety and Depression scores than controls and were more likely to be taking prescribed medications. Thirteen patients with DS (34%) were taking antiepileptic drugs (AEDs), and 16 patients (42%) reported taking antidepressant medications. For the DS group, the median current monthly seizure frequency was 4.33 (interquartile range = 14.6). The median length of time since seizure onset was 54 months (interquartile range = 96.8 months).

3.2. Cognitive tests

A summary of scores on the cognitive tests can be found in Table 2. There were no significant group differences on any of the cognitive tests administered. The groups were, therefore, well matched for cognitive performance and so these scores were not added to the analysis of emotional Stroop performance as covariates.

3.3. Awareness check

Table 3 displays descriptive statistics for the awareness test. Accuracy scores were lower in the DS group for all three conditions; however, after covarying for YoE (which was also lower in the DS group, see above), there was no overall significant effect of group on the percentage of correct responses ($F(1, 78) = 3.28, p = .074, \eta^2_p = .04$). There was also no overall effect of expression ($F(2, 156) = 1.34, p = .27, \eta^2_p = .017$), and no interaction of expression $\times$ group ($F(2, 156) = .402, p = .669, \eta^2_p = .005$). YoE was not a significant

covariate ($F(1, 78) = .012, p = .92, \eta^2_p = .000$). The same pattern was observed when HADS Anxiety and Depression scores were added as covariates, although anxiety did covary significantly with percentage correct scores ($F(1, 76) = 4.27, p = .042, \eta^2_p = .053$); higher anxiety scores were associated with better awareness in all three conditions.

Binomial tests indicated that the mean percentage correct scores for some expressions were above chance in one or both groups (see asterisked values in Table 3). In the DS group, performance was above chance for happy faces, whereas performance was better than chance for angry and happy faces in the control group. Nevertheless, 79% of the DS group and 72% of controls reported no awareness of having seen any facial stimuli during the test at all. Those participants reporting awareness of having seen the stimuli often were not able to report exactly what they had seen (e.g. specific facial expressions).

3.4. Emotional Stroop test

Table 4 displays the descriptive statistics for the emotional Stroop task.

Colour-naming errors

The ANCOVA revealed no significant effect of group on colour-naming errors ($F(1, 76) = 1.81, p = .183, \eta^2_p = .023$); however, a significant effect of expression was evident ($F(1.73, 131.2) = 8.10, p = .001, \eta^2_p = .096$) with neutral expressions associated with most erroneous responses (marginal mean = .21, SE = .091), and happy faces the fewest (marginal mean = .71, SE = .21).

There was no significant group x expression interaction ($F(1.73, 131.2) = 1.11, p = .33, \eta^2_p = .014$). YoE ($F(1, 76) = 6.46, p = .013, \eta^2_p = .078$) and HADS Anxiety ($F(1, 76) = 5.78, p = .019, \eta^2_p = .071$) were significant covariates, but HADS Depression was not ($F(1, 76) = .75, p = .39, \eta^2_p = .010$). Higher Anxiety scores were associated with fewer colour-naming errors in all conditions.

Absolute RTs

No significant main effect of expression ($F(2, 152) = .39, p = .68, \eta^2_p = .005$), group ($F(1, 76) = .21, p = .65, \eta^2_p = .003$), or group x expression interaction ($F(2, 152) = 2.61, p = .077, \eta^2_p = .033$) was observed for absolute RTs. None of the covariates were significant.

Attentional bias scores

The ANCOVA demonstrated a significant group effect for attentional bias (AB) scores ($F(1, 76) = 4.36, p = .04, \eta^2_p = .054$), with the DS group exhibiting significantly greater AB scores (marginal mean = 10.07, SE = 3.98) compared to control participants (marginal mean = -2.57, SE = 3.68). There was no overall effect of expression ($F(1, 76) = .83, p = .37, \eta^2_p = .011$), and no expression $\times$ group interaction ($F(1, 76) = .56, p = .46, \eta^2_p = .007$). The only significant covariate was HADS Depression scores ($F(1, 76) = 4.13, p = .046, \eta^2_p = .052$), with higher depression scores associated with reduced AB scores for both happy and angry faces.

Exploratory analyses

There was a highly significant positive relationship between seizure frequency and AB scores for happy faces ($r = .469, p = .003$), which remained significant after controlling for YoE and HADS scores in a partial correlation ($r = .662, p = .001$). None of the other correlations between participant characteristics and AB scores were significant at an alpha level of $p < .01$.

4. Discussion

This study tested the hypothesis that implicitly processed facial affect would interfere disproportionately with performance on an emotional Stroop test, and that this group effect would not be explained by the presence of anxiety, depression, or differences in relevant cognitive abilities. As predicted, patients with DS showed greater AB scores for facial emotion, relative to the control group, whilst controlling for psychological symptoms (i.e. anxiety, depression). Furthermore, the groups were well matched for performance on relevant cognitive tests, and the awareness check data indicated that there were no between-group differences in awareness of the masked facial stimuli, so it is unlikely that either of these factors explain the findings.

Together with Bakvis et al.'s study [39], these results provide strong evidence for an exaggerated attentional bias for facial emotion in this group; this attentional bias does not appear to be attributable to possible confounding variables. At this stage, it is only possible

to hypothesise about the causation of such a bias. One possible explanation is that individuals with DS are more likely to have experienced childhood family contexts in which emotional expression and experience is inhibited [9,21], and therefore, the 'norm' could be affectively neutral or less intense facial expressions. In this case, outward signals of emotion in others could potentially be particularly salient stimuli for some people with DS, especially the relatively intense expressions such as happiness and anger, used in this study.

An alternative possibility is that the presence of conflict, abuse, and neglect in the histories of some patients with the diagnosis [17,22,52,53] may have contributed to more frequent than average exposure to negative facial expressions, potentially sensitising them to signs of anger/hostility and/or signs of social acceptance or approval. Of relevance to this interpretation are our findings reported elsewhere [17,38] in this same sample, of higher rates of self-reported trauma (including total lifetime traumas, sexual and physical abuse), greater impact of traumas, and more current interpersonal conflict and abandonment concerns, relative to controls. It should be noted; however, that in preliminary correlational analyses, there were no significant relationships between these factors and the AB observed in this experiment.

A final possible explanation for the AB observed here is that it could be secondary to the disorder itself. The presence of this chronic, distressing and debilitating disorder could be sufficient to make patients more socially anxious, and thus excessively alert to signals of threat or acceptance in others. One means of examining the latter possibility is to assess whether the attentional bias ameliorates with resolution of DS symptoms following treatment.

In the present study, the lack of interaction between expression and group in the analysis of AB scores suggested that the attentional bias reflected a tendency towards hypervigilance for both positive and negative facial expressions, in contrast to the specificity of the effect to anger in Bakvis et al.'s study [39]. Other studies have also found differences in responses to positive affective stimuli in this group [54] and effects spanning both positive and negative facial expressions in different paradigms [31]. Additional studies exploring differential responding to positive and negative stimulus categories would be informative in this group. Furthermore, studies aiming to examine attentional biases to other, possibly relevant stimuli

might also be of value, such as those relating to somatic experiences and awareness, illness, or trauma.

An important finding in the current study was that depression scores were found to be a significant covariate throughout the analyses of AB scores. This finding highlights the necessity of controlling for this possible confound in studies of affective processes in this patient group. The finding that elevated symptoms of depression were associated with reduced attentional bias for facial emotion in this sample contrasts with the pattern observed in individuals with depression more generally, in which attentional biases (i.e. greater interference) towards negative (sad) facial expressions have been reported [43,55]. Symptoms of depression in patients with DS might influence affective processing in a different way to individuals with clinical depression without DS, perhaps causing automatic avoidance of affective stimuli as would be suggested by the association with reduced AB scores observed here. Therefore, it would be beneficial to further examine the ways in which symptoms of anxiety and/or depression influence affective processing in patients with DS, compared to individuals with depression/anxiety alone.

The significant relationship between seizure frequency and AB scores for happy expressions suggests that those patients having the most seizures (i.e. greater disorder severity) automatically allocated more attention to positive facial expressions than those with less frequent seizures. This tendency to automatically seek out positive experiences and interpersonal interactions in the environment could represent an aspect of resilience for these individuals. On the other hand, a tendency to attend automatically to positive social cues (or positive stimuli more generally) might serve as a means of reducing or avoiding subjective emotional distress, and this could be a predispositional style of responding that could act as a risk factor for developing the disorder. Further studies might valuably seek to explore these findings further by examining responsivity to both negative/threatening and positive/appetitive stimuli in those with recent onset DS, compared to those with chronic symptoms, and in those whose seizures have remitted.

4.1. Limitations

With regards to the experimental task, there are a few limitations to note. We only included one exemplar of positive and one of negative facial expressions; therefore, we have

not provided information on attentional processing of other possibly relevant expressions such as fear, disgust, or empathy, for example. In addition, the use of a neutral face as a control condition is questionable, because neutral faces could carry emotional significance for people with DS (and other psychological disorders with similar risk factors).

Furthermore, whilst the traditional interpretation of the emotional Stroop task is that it measures attentional bias (facilitated attention) towards specific stimulus categories [56], others have suggested that it might predominantly measure cognitive avoidance or disengagement [57,58]. We would argue that the cognitive avoidance explanation is less plausible for the task used here, because of the short duration of stimulus presentation (17 msec) and associated impaired subjective awareness of the stimuli; cognitive/attentional avoidance is thought to occur at a later stage of processing than the initial precognitive evaluation of stimuli that would operate during the subliminal presentations used here. Future studies might seek to explore further our findings with other attentional processing tasks, such as variations of the visual probe, visual search, or spatial cueing tasks, for example. Tasks that vary stimulus duration, particularly comparing supraliminal and subliminal presentations of stimuli, may also provide insights into the automaticity and/or nature of these cognitive processing differences.

A related point is that the AB findings reported here and by Bakvis et al. [39] were in the order of milliseconds, and so it is questionable whether these group differences are clinically significant. The effect sizes presented here suggest that this may be the case, in addition to the finding that the AB for happy faces was associated with greater seizure frequency. Nevertheless, it would be interesting to examine whether the AB is responsive to psychological treatments, perhaps using prospective before/after treatment designs, and/or to examine whether post-treatment changes in AB for facial affect correlate with other important outcomes, such as self-reported psychosocial functioning, (social) anxiety, mood symptoms, or avoidance behaviours.

In terms of patient recruitment, the present inclusion of patients diagnosed on clinical grounds rather than video-EEG only could leave open the possibility of misdiagnosis; however, we included these individuals to increase statistical power and ensure representativeness of this population, because whilst video-EEG is the current 'gold

standard' in diagnosing DS, it is not currently available universally, and does not definitively exclude the possibility of comorbid epilepsy. Another potential sampling limitation was the lack of a clinical comparison group. Whilst control groups of patients with epilepsy are not appropriate for studies of this nature due to possible differences in facial expression processing in people with that condition [59,60], other suitable comparison groups could be individuals with depression or anxiety without additional medically unexplained symptoms, samples with other functional neurological symptoms (e.g. functional motor or sensory symptoms), or other somatoform disorders.

An additional limitation relating to the clinical sample was the use of AEDs and antidepressants in a proportion of patients, despite the exclusion of comorbid epilepsy (suspected or confirmed) or current affective disorder. Ongoing AED use in this sample might reflect a range of factors, including patients' reluctance to stop taking AEDs due to resistance to a psychological explanation for the disorder, or only gradual withdrawal of AEDs by clinicians to avoid a potential nocebo effect. Antidepressant medications were prescribed for patients in this sample for a range of reasons, including previous affective disorder, anxiety disorders, or other functional neurological symptoms (e.g., fatigue, pain). Given the similar results observed in an unmedicated sample by Bakvis et al., it is unlikely that medication use fully accounts for the findings reported here; however, it remains a possibility that it may have had some influence.

Finally, the inclusion of anxiety and depression as covariates in the ANCOVAs could be queried because these symptoms could be viewed as a part of the disorder itself, in line with arguments presented by Miller and Chapman [61], for example. However, we argue that this suggestion is not applicable here, for several reasons. Anxiety and depression are not a formal part of the diagnosis of DS, and whilst these symptoms are often elevated in this group relative to non-clinical controls, this is not always the case, with many patients reporting no subjective psychological symptoms and a large proportion of DS patients who do not have a comorbid psychiatric diagnosis. Furthermore, many patients with DS experience symptoms of anxiety and depression secondarily to the distressing and disabling disorder itself. As such, whilst anxiety and depression are common comorbidities of DS, they are not inherently part of the disorder, and as such we feel that our approach is valid and preferable to having not measured nor accounted for the presence of these symptoms.

As suggested above, future studies might seek to include clinical control groups with comparable anxiety/depression symptoms, as an alternative approach to exploring this issue.

4.2. Clinical implications

The findings presented here have several potential clinical implications, particularly in the context of the broader findings on emotional processing in this and related populations, such as other functional neurological or dissociative disorder subgroups. A pattern of preconscious hypervigilance to facial emotion (i.e., scanning the environment for social emotional cues), combined with conscious misinterpretation of facial expressions as demonstrated in this same sample [38] or deficits in ‘theory of mind’ reported by others [62], could be associated with substantial difficulties in social interactions in daily life and possibly within psychological interventions for the disorder. These biases, therefore, may play an important role in maintaining the disorder, and possibly precipitating individual seizures. Psychological interventions aimed at reducing preconscious attentional allocation to facial emotion (i.e., attentional bias modification), and improving explicit facial expression recognition and mentalising (e.g., within CBT protocols), might well yield significant benefits for some patients with this disorder.

5. Conclusions

The results of the study provide additional support for the proposal of an exaggerated attentional bias towards implicitly processed emotional facial expressions in patients with DS. Such an attentional bias might contribute to an acute increase in affective arousal when signs of emotion are detected, and thus could directly contribute to the triggering of individual seizures. Moreover, the hypervigilance to subtle signs of affect in others might also contribute to generally elevated arousal on an ongoing basis. Further research is needed to explore attentional biases in this group, using a wider range of experimental paradigms, and in relation to other relevant stimuli. Additionally, future studies in this area might attempt to better ascertain the clinical significance of the findings reported here, particularly in patients at different stages in the disorder (i.e., recent onset, chronic symptoms, in remission) and/or at different points in treatment (i.e., before/after).

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Conflict of interest

None.

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Table 1. Participant characteristics

	DS (n = 38)	Controls (n = 43)	Test statistics
Age (years)			U (81) = 720,
Median (IQR)	41.5 (22.5)	36 (20)	p = .358
Gender	Male = 8 (21%) Female = 30 (79%)	Male = 8 (19%) Female = 35 (81%)	X^2 (1, n = 81) = .076, p = .782
Handedness	Right = 29 (76%)	Right = 38 (88%)	X^2 (1, n = 81) = 2.05, p = .152
Ethnicity	White = 30 (79%) Non-white = 8 (21%)	White = 28 (65%) Non-white = 15 (35%)	X^2 (1, n = 81) = 1.9, p = .168
YoE			U (81) = 616,
Median (IQR)	13 (3.25)	14 (5)	p = .054
Qualifications	GCSEs / none = 14 (37%) Further / higher = 24 (63%)	GCSEs / none = 9 (21%) Further / higher = 34 (79%)	X^2 (1, n = 81) = .251, p = .113
Medication use	Yes = 27 (71%) No = 11 (29%)	Yes = 10 (23%) No = 33 (78%)	X^2 (1, n = 81) = 18.6, p < .001
Medical diagnosis	Yes = 23 (61%) No = 15 (39%)	Yes = 6 (14%) No = 37 (86%)	X^2 (1, n = 81) = 19.04, p < .001
HADS (Mean, SD)			
Anxiety	9.68 (4.07)	5.28 (3.20)	t (79) = -5.44, p < .001
Depression	7.21 (4.23)	2.26 (2.43)	t (57.4) = -6.35, p < .001

SD = standard deviation

YoE: years of full-time education (or equivalent)

IQR = interquartile range

HADS = Hospital Anxiety & Depression Scale

Table 2. Cognitive measures

	DS	Controls	Test statistics
WASI			$t(79) = 1.29,$
FSIQ (Mean, SD)	104.1 (14.7)	108.1 (13.1)	$p = .198$
Vocabulary T scores			$t(79) = 1.46,$
(Mean, SD)	51.8 (11.3)	55.2 (9.8)	$p = .148$
Matrix Reasoning T scores			$U(81) = 730,$
(Median (IQR))	54.5 (10)	56 (15)	$p = .410$
BFRT			$U(80) = 631,$
Median (IQR)	49 (7)	49 (5)	$p = .109$
Stroop test	52.8 (8.3)	51.5 (9.01)	$t(78) = -.656,$
Mean (SD)			$p = .514$

SD = standard deviation; WASI = Wechsler Abbreviated Scale of Intelligence; FSIQ = Full-Scale IQ; DS = dissociative seizures; IQR = interquartile range; BFRT = Benton Facial Recognition Test

Table 3. Awareness check for subliminally presented stimuli

	DS (n = 38)	Controls (n = 43)
Angry faces (% correct)		
Mean (SD)	42.1 (24.2)	53.3 (24.7)*
Neutral faces (% correct)		
Mean (SD)	46.1 (23.3)	50.2 (25.9)
Happy faces (% correct)		
Mean (SD)	52.9 (22.9)*	60 (29.2)*

DS = dissociative seizures; SD = standard deviation; IQR = interquartile range

* denotes variables significantly differing from chance performance ($p < .01$)

Table 4. Emotional Stroop test – descriptive statistics (uncorrected values)

	DS (n = 38)	Controls (n = 43)
Colour-naming errors (%; mean, SD)		
Happy	.18 (.75)	.23 (.86)
Angry	.53 (1.82)	.23 (1.13)
Neutral	.61 (1.31)	.78 (2.28)
Absolute RTs (msecs; mean, SD)		
Happy	622.9 (94.9)	603.1 (79.8)
Angry	622.4 (93.4)	605.5 (80.6)
Neutral	617.1 (97.7)	602.9 (83.9)
AB scores (msecs; mean, SD)		
Happy	5.79 (27.6)	.207 (20.6)
Angry	5.31 (27.1)	2.65 (21.6)

Supplementary Material

Supplementary file I – Experimental stimuli

Example facial stimuli

Full list of facial stimuli (from Ekman & Friesen, 1976)

Experimental stimuli: 001, 003, 006, 014, 018, 021, 029, 030, 033, 034, 038, 041, 042, 044, 047, 048, 053, 056, 057, 061, 065, 074, 080, 083, 093, 096, 099, 101, 105, 110

Masking stimuli