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# Attentional processing biases to threat in schizophrenia: Evidence from a free-viewing task with emotional scenes

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ABSTRACT

Attentional biases to threatening stimuli have been suggested to play a key role in the onset and course of schizophrenia. However, current research has not completely demonstrated this assumption. The aim of this eye-tracking study was to shed light on the underlying psychological mechanisms of schizophrenia by examining the attentional processing of socio-emotional information. Forty-four individuals with schizophrenia and 47 healthy controls were assessed in a 3-s free-viewing task with a social scene (i.e., happy, threatening, or neutral) in competition with a non-social one to determine the effects of emotional information on the different stages of the attentional processing. The location and latency of initial fixations (i.e., initial orienting), the firs-pass fixations and gaze duration (i.e., attentional engagement), and the percentage of total duration and total fixations (i.e., attentional maintenance) were analyzed. It was found that the schizophrenia group showed longer first-pass gaze duration, as well as higher percentage of total fixations and total duration toward threatening scenes in relation to the non-social ones, compared to controls. Therefore, an attentional bias toward threatening scenes in schizophrenia was found in the attentional maintenance and engagement, but not in the initial orienting of attention. Of note, the threat-related attentional bias was not associated with positive symptoms of schizophrenia. These findings offer empirical support to affective-information processing models stating that threatening information may confer psychological vulnerability to develop schizophrenia. Moreover, the results can improve psychological treatments, such as attentional bias modification paradigms or cognitive-behavior interventions managing maladaptive schemas related to threat.

## 1. Introduction

Schizophrenia (SZ) is a severe mental disorder characterized by positive (e.g., hallucinations, delusions) and negative symptoms (e.g., apathy, flat-affect), that lead toward social dysfunction (American Psychiatric Association, 2013). SZ symptoms and social dysfunction have been linked to socio-cognitive and emotional abnormalities (Cohen et al., 2011). Indeed, attentional biases to emotionally relevant contents, such as threatening information, have been suggested as an underlying mechanism of the onset and course of SZ (Bentall et al., 2007). However, research on attentional biases in SZ is inconclusive (Savulich et al., 2012), thereby raising doubts on: i) the attentional processing stages that are affected; ii) which emotional valence (e.g., pleasant, unpleasant) and stimulus type (e.g., words, faces, scenes) are abnormally processed; and iii) whether attentional biases are a trait of SZ or are restricted to specific SZ symptoms. In this study, a group of SZ patients were asked to free-view social scenes (i.e., happy, threatening, neutral) in competition with a non-social one. Meanwhile, eye movements were recorded to gain knowledge on the underlying psychological mechanisms of SZ.

At a theoretical level, affective information-processing theories suggest that biased attention toward pathology congruent emotional information triggers cognitive abnormalities leading to psychiatric symptoms (Beck et al., 1979). Pathology congruent

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information-processing biases are a tendency for the information processing system to consistently favor stimulus material whose content matches the symptoms and concerns of the pathology itself (Savulich et al., 2012). This theoretical framework of information processing was later developed by Bentall (1992) to explain the psychological mechanisms underlying SZ. In this regard, a key factor in the development of SZ is a maladaptive appraisal of the reality characterized by personalized threat (Underwood et al., 2016). This maladaptive appraisal may give rise to hypervigilance toward threatening information, which has been proposed as a cause of attentional biases in SZ (Green et al., 2003). Thus, attentional biases to threat may play a central role in the onset and maintenance of SZ symptoms (Blackwood et al., 2001). As for auditory hallucinations, the threat-related bias may have an etiological role in their onset (Garety et al., 2001), since altered emotional states together with hypervigilance for threatening stimuli interact to increase the likelihood of hallucinations, especially in those with intimidating content (Dodgson and Gordon, 2009). Regarding persecutory delusions, scanning the environment for threats has been associated with the emergence of these symptoms as well as with related anomalous experiences (Bentall et al., 2001; Freeman et al., 2002; Green and Phillips, 2004). More specifically, Bentall et al. (2001) proposed that threats to the self-esteem result in external attributions that, together with attentional biases toward threatening information, are implicated in the etiology of persecutory delusions to defense paranoid individuals from depressive symptoms. Similarly, Freeman et al. (2002) argued that attentional biases toward threatening information contribute to maintain paranoid beliefs in individuals with SZ searching for a meaning of the negative internal emotional experiences. Whereas these theories posit an attraction of threatening material, Green and Phillips (2004) suggested a more complex attentional pattern depending on the attentional stage assessed. They hypothesized a "vigilance–avoidance" behavior, where threat-related stimuli would capture early attention, followed by a strategic avoidance behavior to reduce the anxiety associated to patients with SZ and persecutory delusions. Likewise, it has also been suggested that this "vigilance-avoidance" pattern would also indicate that individuals with SZ draw precipitated conclusions about what they see and do not seek more information, resulting in an avoidance behavior to threat-related information (Phillips et al., 2000). In this sense, attentional biases in SZ may actually be driving the 'data gathering' bias, which is related to the etiology of persecutory delusions (Savulich et al., 2012). Additionally, attentional biases to threat have been associated with the negative symptoms in SZ. For instance, chronic negative mood and social withdrawal in SZ can be explained by the maintenance of attention on threatening information (Beck and Rector, 2005; Strauss et al., 2008). In sum, based on leading theoretical accounts, attentional biases toward threat may be involved in the etiology of a wide range of SZ symptoms and, hence, they might be a disorder trait marker as well.

Previous research on attentional biases that have employed response time-based tasks were mainly designed to test cognitive theories related to the formation of persecutory delusions with non-clinical participants (Arguedas et al., 2006; Green et al., 2001), or with paranoid participants only (Bentall and Kaney, 1989; Taylor and John, 2004). Although these studies have demonstrated that threatening information captures the attention in these patients, results cannot be extrapolated to SZ. Indeed, studies assessing a representative sample of SZ patients have obtained conflicting results. Whereas some studies have reported an attentional bias toward threat (see Moritz and Steffen, 2007, for a cueing task with threatening, anxious, and neutral social scenes; Besnier et al., 2011, for a Stroop task with depressive, manic, threatening, and neutral words), others have shown no attentional bias (Demily et al., 2010; Feroz et al., 2019, for Stroop tasks with positive/negative words). This lack of bias may be attributable to: i) the use of nonspecific threatening stimuli; or ii) the heterogeneity of the experiments, which tap into different attentional processes (Bar-Haim et al., 2007).

Despite the fact that reaction-time tasks offer highly valuable information on emotional processing, they only show one data point at the end of the information processing. In order to deepen knowledge, it is essential to examine how threatening information impacts different attentional stages (Savulich et al., 2012). Recording eye movements allows examining the full time-course of attentional processing with several measures (Kellough et al., 2008): (i) location and latency of first fixation (initial orienting of attention); (ii) first-pass fixations and gaze duration (attentional engagement); or (iii) the total number of fixations and total duration (attentional maintenance). Another valuable contribution of eye-tracking is that it allows obtaining a measurement of attentional allocation when several complex stimuli are presented simultaneously and compete for the observer's attention, which is a more ecologically valid setting than displaying stimuli individually (Fletcher-Watson et al., 2009).

Despite that eye-tracking is considered an excellent technique for assessing information-processing bias, only a few studies have been performed on SZ, mostly displaying visual stimuli individually. When eye-tracking studies have been restricted to paranoid SZ patients, an attentional maintenance bias away from unpleasant stimuli in late stages of processing has been found in both social scenes (Phillips et al., 2000) and faces (Green et al., 2003), which was interpreted in the context of the "vigilance-avoidance" hypothesis. Finding these biases only in paranoid SZ patients may imply that they are state-markers of persecutory delusions. Conversely, when other authors have employed samples with SZ diagnosis (not only patients suffering from persecutory delusions), an attentional bias toward threat has been found with scenes (Navalón et al., 2021; Strauss et al., 2015), but not with faces (Jang et al., 2016). Strauss et al. (2015) designed a directed attention task with a threatening scene displayed for 3 s. The individuals with SZ showed difficulties in disengaging their attention from threatening areas of the scene, suggesting an attentional engagement bias toward threat. In a free-viewing task study (Navalón et al., 2021), participants were required to scan/re-scan four complex socio-emotional images (happy, sad, threat, and neutral) simultaneously displayed for 20 s, and an attentional engagement and maintenance bias toward threat was found. Otherwise, Jang et al. (2016) performed a dot-probe task with SZ patients recording the eye movements and displaying pairs of emotional (i.e., angry, happy, or sad) and neutral faces during 1500 ms. They found no differences between SZ patients and controls when comparing emotional to neutral faces in the initial orienting and in the subsequent attentional engagement. Authors argued that the small sample (19 controls, 22 SZ) had the potential to underpower discerning subtle group differences. Moreover, the attentional bias may not emerge in relatively early (1500 ms) attentional stages of the processing, as a result of a delay in processing complex emotional information (Quirk et al., 2001). Additionally, using faces instead of scenes may also explain the lack of bias in Jang et al. (2016). Of note, socio-emotional information needs to be gathered not only by processing other people's faces, but also their body posture, gestures, and contextual elements (Nikolaides et al., 2016). Thus, the current eye-tracking evidence suggests that the use of simple stimuli (e.g., faces instead of scenes) and the examination of too early attentional processing stages (i.e., <1500 ms) may be a low sensitive method to assess the attentional bias in SZ.

In sum, the current evidence regarding attentional biases toward threat in SZ patients is heterogeneous, which may be related to the measurement of the different stages of attentional processing. In addition, the use of simple stimuli (words or faces) without specific threatening content, or not assessing the effect of psychopathology, can also explain the lack of conclusive findings in some studies. Thus, the main goal of the present experiment is to assess the full-time course of the processing of threatening complex scenes in a sample of SZ patients, considering the effect of psychopathology.

According to the theories suggesting that the threat-related bias has an etiological role in SZ, it is expected that the attentional bias occurs toward threatening scenes rather than in other social scenes (Bentall, 1992; Savulich et al., 2012; Underwood et al., 2016). Regarding the

attentional stage, it is expected that the bias would be demonstrated in later stages (attentional engagement and maintenance) rather than in the earliest one (initial orienting), given that the complexity of the stimuli requires that participants take additional time to identify them (Quirk et al., 2001). That is, the SZ group would show a higher number of first-pass fixations, higher gaze duration, and higher percentage of total duration and total fixations on the threatening stimuli, compared to the control group (see Navalón et al., 2021 and Strauss et al., 2015, for similar findings). Finally, following the "vigilance–avoidance" hypothesis for persecutory delusions in SZ, suggesting an early attraction followed by an avoidance behavior associated to threat-related information (Green and Phillips, 2004), positive symptoms would be related to an earlier attentional bias towards threat (i.e., an association between the intensity of positive symptoms and the initial orienting of attention), but a later attentional bias away from threat (i.e., an inverse association between the intensity of positive symptoms and the percentage of total duration and total fixations).

## 2. Methods

### 2.1. Participants

Forty-four SZ participants were referred by their psychiatrists, and 47 healthy individuals were recruited through advertising. The SZ group was composed by a highly representative sample: i) 50% of patients were stable outpatients recruited from a psychosis rehabilitation center or from mental health units, and the other 50% were inpatients recruited from an acute unit; ii) whereas 13 patients did not suffer from paranoid symptoms, defined by < 3 in the "persecutory delusions" item of the *Positive and Negative Syndrome Scale (*PANSS; Kay et al., 1987), 34 showed paranoids symptoms in some extent; iii) both early onset and chronic patients were assessed (illness duration range 2–45 years); iv) patients showed varied sociocultural characteristics (e.g., 24 patients had completed secondary or university education, 20 patients had completed only primary studies). Socio-demographic and clinical data are detailed in Table 1.

Inclusion criteria was 18–65 years for all participants, and a SZ diagnosis for the clinical group following DSM-5 (American Psychiatric Association, 2013) criteria. The SZ diagnosis was corroborated by a psychiatrist by means of a semi-structured clinical interview based on the *Structured Clinical Interview for the DSM-5* (First, 2015). Exclusion criteria: neurological disorders (e.g., epilepsy, intellectual disability); visual/calibration problems; major medical disorders; electroconvulsive therapy within the previous 3 months; and taking non-psychotropic medication that could influence cognition (e.g., corticosteroids, opioids). Additionally, controls with a history of psychiatric conditions were excluded.

The study was approved by an ethics committee, all subjects signed informed consent.

### 2.2. Materials

To assess the severity of affective symptoms when performing the task and their relation with eye-tracking measurements, all participants completed the *Beck Depression Inventory II* (BDI-II; Beck et al., 1996) and the *State Anxiety Inventory* (STAI-S; Spielberger et al., 1983). Additionally, the PANSS (Kay et al., 1987) was administered to the SZ group to evaluate the positive and negative symptoms severity. These three questionnaires have good psychometric properties and reliability for assessing psychotic and affective symptoms and have been widely employed in clinical research (Barnes et al., 2002; Peralta and Cuesta, 1994; Wang and Gorenstein, 2013).

### 2.3. Stimuli

The stimuli included 128 scenes selected from the *International Affective Picture System* (Lang et al., 2005). This image set is standardized and used extensively in studies of psychopathology. The image set was selected following Nummenmaa et al. (2006). A previous study administered an emotional discrimination task with the same image set that is employed in this experiment to participants with severe mental illness, finding less than 1% of errors when patients discriminated the emotional content of the stimuli (García-Blanco et al., 2015).

Sixteen happy, 16 threatening, and 16 neutral target social scenes were chosen. Happy target scenes represented people showing agreeable affect. Threatening target scenes depicted hostile people or people suffering from a threat. Neutral target scenes represented people in quotidian activities. Eighty control non-social pictures representing inanimate objects were chosen. The valence rating was higher for the happy than for the threatening and control pictures, whereas the valence rating was higher for neutral pictures and control than for threatening pictures. Valence ratings for neutral target and control pictures did not differ from each other. Regarding arousal, no significant difference between the happy and the threatening stimuli and between the neutral and the control stimuli were found. However, arousal rating was higher for the happy than for the neutral pictures and the control pictures. Arousal rating was also higher for the threatening than for the neutral pictures and the control pictures.

A total of 64 trials (48 study + 16 fillers) were presented to each participant. Each trial included two randomly paired images, resulting in three groups of experimental trials (16 happy-control, 16 threatening-control, 16 neutral-control). Sixteen pairs of neutral-control pictures

**Table 1**
Sociodemographic and clinical data.

| | *Control (N = 45)* | *SZ (N = 44)* | p |
|---|---|---|---|
| *% FEMALE* | 53 | 45 | .66 |
| *AGE* | 37.2 (13.1) | 40.4 (11.2) | .21 |
| *STAI-T* | 13.3 (8.8) | 26.7 (11.1) | <.001 |
| *STAI-S* | 11 (6.2) | 24.8 (10.2) | <.001 |
| *BDI-II* | 4.4 (5.6) | 9.7 (7.8) | <.01 |
| *PANSSG* | | 45.3 (10) | |
| *PANSSP* | | 21.6 (5.7) | |
| *PANSSN* | | 24.5 (7.1) | |
| *ILLNESS DURATION* | | 18.65 (11.5) | |
| *AGE OF ONSET* | | 27 (10.2) | |
| *EDUCATION (n)* | | | .009 |
| | 15 | 20 | |
| Primary studies | 11 | 18 | |
| | 19 | 6 | |
| Secondary studies | | | |
| University studies | | | |
| *TREATMENT* | | | |
| % ANTIPSYCHOTIC | | 100 (44) | |
| %FGA | | 9.1 (4) | |
| %SGA | | 81.8 (35) | |
| %Both | | 9.1 (4) | |
| CED | | 813.4 (518.8) | |
| % ANTIDEPRESSANT | | 22.7 (10) | |
| %SRI | | 11.4 (5) | |
| %SNRI | | 6.8 (3) | |
| %Tricyclic | | 4.5 (2) | |
| % BENZODIAZEPINE | | 63.6 (28) | |
| *DED* | | 22.4 (29.1) | |
| % ANTIEPILEPTIC | | 11.4 (5) | |

*Note.* BDI-II: Beck Depression Inventory-II; CED: Chlorpromazine Equivalent Dose; DED: Diazepam Equivalent Dose; FGA: First Generation Antipsychotic; PANSSG: Positive and Negative Syndrome Scale: General Psychopathology Scale; PANSSP: Positive and Negative Syndrome Scale: Positive Psychopathology Scale; PANSSN: Positive and Negative Syndrome Scale: Negative Psychopathology Scale; SGA: Second Generation Antipsychotic; SNRI: Serotonine and Norepinephrine Reuptake Inhibitor; SRI: Serotonine Reuptake Inhibitor; STAI-T/S: State-Trait Anxiety Inventory-Trait/State; SZ: Schizophrenia Group; The *p* values correspond to the omnibus test for both groups.

were included as filler trials. Each trial began with an initial central cross. A fixed gaze made it disappear. The presentation duration was 3 s.

The paired pictures were presented in two opposing corners of the screen (top left/bottom right or top right/bottom left). The horizontal and vertical locations of the target pictures were balanced across trials, with the constraint that each stimulus category appeared in each of the four positions four times across 16 trials. The presentation order of the images was randomized across participants. The position, the variation in the image locations and the randomization of trials guaranteed that the participants were not able to use any predetermined scanning strategy.

### 2.4. Apparatus

A remote eye-tracking system (SMI RED250) was used to measure the participants' eye movements. The system allows a free range of head movement. The sampling rate of the eye positions was 250 Hz.

### 2.5. Procedure

Firstly, all participants signed the informed consent, and answered to a demographic interview and to the BDI-II/STAI questionnaires. Separately, a psychiatrist had completed the clinical interview and the PANSS. Secondly, participants carried out the task individually in a quiet room. They were seated 60 cm away from the screen in a height-adjustable chair. The experimental session began once the eye-tracker was calibrated (average error was less than 1.5° of the visual angle for each calibration point) and six practice trials were completed. Instructions appeared on the screen, "look at the images as if you were watching television or looking to a photo album". The experimenter was placed in the same room during the procedure, monitoring the task (see García-Blanco et al., 2014, for a similar study in bipolar disorder).

### 2.6. Data analysis

Data were computed using a velocity-based algorithm with a minimum fixation duration threshold of 100 ms and a peak velocity threshold of 40°/s. The areas of interest corresponded to the total area for each scene.

The measurements computed were: (i) latency of initial fixation (time taken to fixate a target scene for the first time); (ii) probability of initial fixation (probability that the initial fixation land on the target scene); (iii) gaze duration (sum of fixation duration made on the target scene when looking at it for the first time); (iv) number of first-pass fixations (number of fixations on the target scene when looking at it for the first time); (v) percentage of total fixations (the percentage of times that each participant fixated, and re-fixated, on the socio-emotional target image during the 3 s period, compared to the non-social control one); (vi) percentage of total duration (the percentage of fixation time attending to the socio-emotional target scene during the 3 s period, compared to the non-social control one). All measures were averaged across the trials.

Each eye movement measure was analyzed in a 2 (Group: control, SZ) x 3 (Valence: neutral, happy, threatening) repeated measures analysis of variance (ANOVA) in which Group was a between-subjects factor, and Valence was a within-subject factor. If the interaction between the two factors was significant, we conducted simple effects tests, which were analyzed by Bonferroni comparisons.

To characterize the relation between attentional biases to threatening information and paranoid symptoms, we performed correlational analyses. The PANSS positive subscale score was correlated with the eye-tracking variables for threatening scenes, due to the previous finding suggesting an association between persecutory delusions and the attentional bias to threat (Green et al., 2003).

The association between antipsychotics and benzodiazepines dose and all the eye-tracking variables was assessed with two-tailed Spearman's correlations.

The analyses were adjusted for multiple comparisons with the Holm-Bonferroni method (Holm, 1979; von der Malsburg and Angele, 2017) using the MultipleTesting.com tool (Menyhart et al., 2021).

## 3. Results

Descriptive data are displayed in Table 2. Double interactions were significant at $p \leq .015$ after the Holm-Bonferroni correction.

### 3.1. Latency of the initial fixation

The ANOVA of the latency of initial fixation showed that the effect of Valence approached significance, $F(2,178) = 2.27$, $p = .068$, $\eta^2 = 0.03$. Neither the effect of Group nor the Valence × Group interactions were significant (all $Fs < 1$).

### 3.2. Probability of initial fixation

The ANOVA of the probability of initial fixation revealed an effect of Valence, $F(2,178) = 7.850$, $p = .001$, $\eta^2 = 0.081$. Bonferroni-adjusted comparisons showed that the participants' initial fixations were most likely directed toward happy, M = 62.77%, CI95% [1.87–10.04], $p = .002$; and threatening scenes, M = 62.45%, CI95% [1.11–10.14], $p = .009$; than toward neutral ones (M = 56.82%). Neither the Group effect nor the Valence × Group interaction were significant (all $Fs < 1$).

### 3.3. Gaze duration

The ANOVA of the gaze duration revealed an effect of Valence, $F(2, 178) = 7.23$, $p = .001$, $\eta^2 = 0.075$, which was qualified by a Valence × Group interaction, $F(2, 178) = 7.41$, $p = .001$, $\eta^2 = 0.077$). No significant Group effect was found ($p > .01$).

To examine the Group × Valence interaction, we conducted simple effects tests of Group for each level of Valence. Whereas no between-group differences were demonstrated for happy ($p = .157$) or neutral stimuli ($p = .891$), a significant difference was found for threatening stimuli, indicating longer gaze duration for the SZ group than for the control group, $F(1, 89) = 4.394$, $p = .041$, $f = 0.21$. See Fig. 1a.

### 3.4. First-pass fixations

The ANOVA of the number of first-pass fixations revealed an effect of Valence, $F(2, 178) = 7.753$, $p = .001$, $\eta^2 = 0.08$, and Group, $F(1, 89) = 11.589$, $p = .001$, $\eta^2 = 0.115$, which was qualified by a Valence × Group interaction, $F(2, 178) = 4.324$, $p = .015$, $\eta^2 = 0.046$.

The Group × Valence interaction was analyzed with simple effects tests. The control group showed higher number of first-pass fixations than the SZ group for neutral, $F(1, 89) = 21.017$, $p < .001$, $f = 0.48$, happy, $F(1, 89) = 8.601$, $p = .004$, $f = 0.26$, and threatening social scenes, $F(1, 89) = 4.427$, $p = .038$, $f = 0.21$, compared to the control non-social ones. Fig. 1b.

### 3.5. Percentage of total fixations

The ANOVA of the percentage of total duration revealed an effect of Valence, $F(2, 178) = 17.433$, $p < .001$, $\eta^2 = 0.164$, an effect of Group, $F(1, 89) = 5.577$, $p = .02$, $\eta^2 = 0.059$, and a significant interaction between the two factors, $F(2, 178) = 7.915$, $p = .001$, $\eta^2 = 0.082$.

Simple effects tests showed that the percentage of total fixations to threatening stimuli was higher for the SZ group than for the control one, $F(1, 89) = 15.848$, $p < .001$, $f = 0.28$. No significant differences among groups were found for neutral ($p = .605$) or happy stimuli ($p = .157$). See Fig. 2a.

**Table 2**
Mean (standard deviation) for the latency and probability of first fixations; the first-pass fixations and gaze duration; and the percentage of total fixations and total duration for each stimulus category across the trials for the control (C) and the schizophrenia (SZ) groups.

| Valence | Latency of first fixations (ms) | | Probability of first fixation (%) | | Gaze duration (ms) | | First-pass fixations (number of fixations) | | Percentage of total duration (%) | | Percentage of total fixations (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C | SZ | C | SZ | C | SZ | C | SZ | C | SZ | C | SZ |
| *Neutral* | 830 (33) | 839 (34) | 56.11 (1.81) | 57.54 (1.87) | 828 (45) | 837 (46) | 3.45 (.12) | 2.68 (.12) | 53.74 (1.19) | 54.00 (8.1) | 53.0 (7) | 52.2 (7.2) |
| *Happy* | 768 (35) | 802 (37) | 63.36 (1.73) | 62.19 (1.79) | 838 (50) | 941 (52) | 3.57 (.13) | 3.01 (.14) | 56.12 (1.63) | 59.80 (11.7) | 55.7 (9.2) | 58.7 (10.3) |
| *Threat* | 781 (36) | 789 (38) | 60.91 (1.94) | 63.99 (2.01) | 822 (50) | 971 (52) | 3.47 (.13) | 3.1 (.14) | 56.77 (1.42) | 63.95 (9.4) | 54.7 (9.2) | 62.3 (9) |

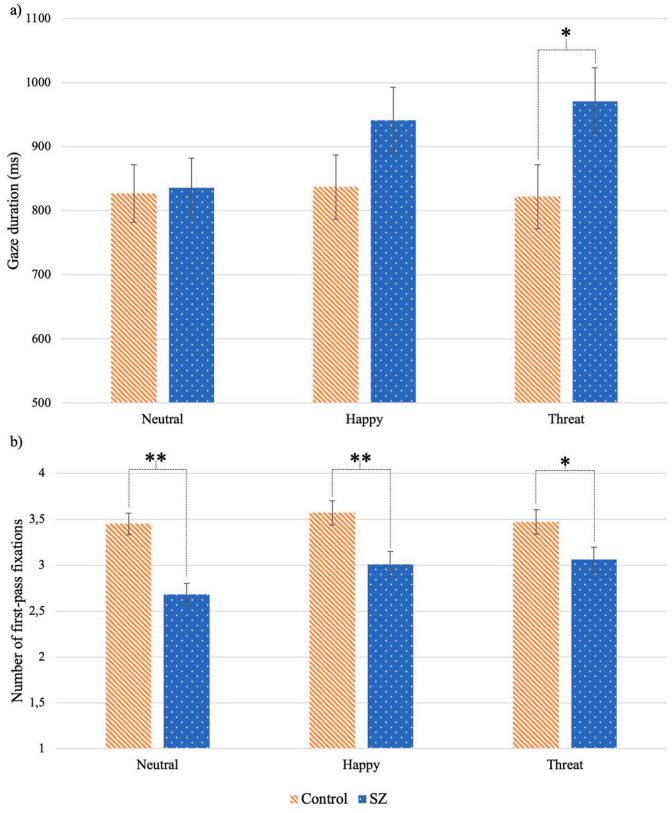


**Fig. 1.** Gaze duration (a), and number of first-pass fixations (b) on the target scenes for both groups. *p < .05. **p ≤ .01.

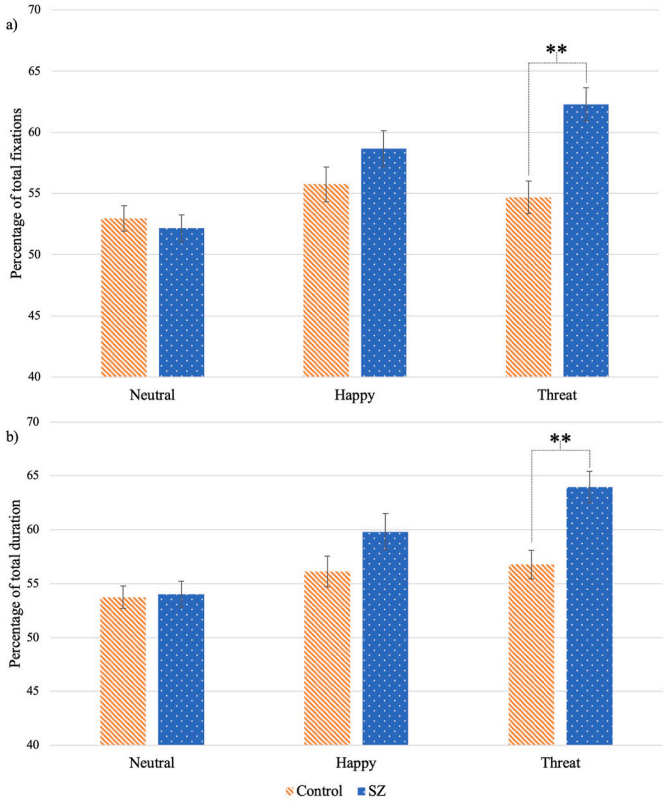


**Fig. 2.** Percentage of total fixations (a), and percentage of total duration (b) on the target scenes for both groups. **p ≤ .01.

### 3.6. Percentage of total duration

The ANOVA of the percentage of total duration showed a significant effect of Valence, $F(2, 178) = 17.245$, $p < .001$, $\eta^2 = 0.162$, and Group, $F(1, 89) = 5.426$, $p = .022$, $\eta^2 = 0.057$. The Valence × Group interaction was also significant, $F(2, 178) = 4.79$, $p = .01$, $\eta^2 = 0.051$.

This interaction showed that the percentage of total duration to threatening stimuli was higher for the SZ group than for the control one, $F(1, 89) = 12.408$, $p = .001$, $f = 0.34$, whereas there were no significant differences across groups for neutral ($p = .88$) and happy stimuli ($p = .12$). See Fig. 2b.

### 3.7. Correlational analyses

To assess the association between attentional biases to threatening information and the positive symptoms severity, the relation between eye-tracker variables to threat and the PANNS positive subscale score was analyzed. The Spearman correlations did not reveal any significant association (all *ps* > .3).

Given that there were significant between-group differences on the scores of the STAI-S and BDI-II, the association between eye-tracker variables and these psychopathological outcomes were also analyzed in both groups. Two-tailed Spearman's correlations were used for the exploratory analyses. The BDI-II score and the percentage of total fixations to threatening scenes ($r_s = .544$, $p < .001$) were significantly associated in the SZ group. No other significant correlations were found in the SZ group nor the control group after the Holm-Bonferroni correction (all *ps* > .01).

No significant associations were found when assessing the association between antipsychotic (chlorpromazine equivalent dose) and benzodiazepine (diazepam equivalent dose) and all the eye-tracking variables after the Holm-Bonferroni correction (all *ps* > .01).

## 4. Discussion

This investigation represents the first examination of attentional biases during the free-viewing of different socio-emotional scenes (i.e., happy, neutral, threatening) in competition with non-social ones in SZ,

considering the full time-course of attentional processing. The main findings can be summarized as follows: i) an attentional bias was found in SZ in attentional engagement (i.e., gaze duration and first-pass fixations), and attentional maintenance (i.e., percentage of total duration and percentage of total fixations), but not in the initial orientation (i.e., latency and probability of the initial fixation); ii) only threatening scenes elicited the attentional bias; and iii) the threat-related bias was not associated with positive symptoms severity.

Regarding the attentional processing stages, the SZ group showed higher percentage of total fixations and total duration on threatening scenes in relation to non-social ones, compared to controls, indicating an attentional maintenance bias toward threatening information in SZ. Moreover, patients with SZ also showed higher gaze duration on threatening scenes, suggesting an attentional bias to threat in the attentional engagement stage. These findings are congruent with Strauss et al. (2015) and Navalón et al. (2021), demonstrating an attentional engagement and maintenance bias toward threat-related scenes. Of note, regarding the other attentional engagement measurement (number of first-pass fixations), control subjects made more fixations on neutral, happy, and threatening scenes than patients did. However, this difference was lower for threatening scenes. In this regard, it has been demonstrated that individuals with SZ show a restricted scanning style (i.e., less number of fixations) during visual exploration of negative emotional faces (Green et al., 2003) and social scenes (Li et al., 2020). Therefore, a more restricted exploratory strategy for happy and neutral scenes, compared to threatening ones, might indicate a normalization of gaze behavior in SZ when threatening information is displayed. This suggests an emotional advantage for this emotion, and thus, an attentional engagement bias toward threat in the number of first-pass fixations. Another possible explanation is that the attentional bias to threat is less clear in earlier processing stages (initial orienting and attentional engagement) because SZ individuals require an additional time to identify complex socio-emotional stimuli (Quirk et al., 2001). Moreover, the number of first-pass fixations may be a less sensitive measure than gaze duration to assess attentional bias. In sum, the results suggest a threat-related bias in later attentional stages rather than in earlier ones in SZ when displaying social scenes.

Considering the type of stimuli, this experiment revealed that pathology-relevant socio-emotional complex stimuli give rise to abnormal attentional patterns in SZ. Thus, it is possible that only experiments employing complex stimuli depicting socially threatening scenes (Moritz and Steffen, 2007; Navalón et al., 2021; Strauss et al., 2015) or simpler stimuli but with specific pathology-congruent content (Besnier et al., 2011, SZ-related words) would be able to elicit an attentional bias. In this regard, two studies using positive/negative words failed to find an attentional bias (Demily et al., 2010; Feroz et al., 2019). Similarly, another study employing faces (Jang et al., 2016) did not find an attentional engagement bias to threat-related material. Of note, in terms of ecological validity, employing faces as stimuli may be a potential shortcoming. As in real-world situations, social information needs to be gathered not only by processing other people's faces, but also their body posture and gestures as well as contextual elements (Nikolaides et al., 2016).

Finally, this experiment has demonstrated that a highly representative sample of SZ individuals (i.e., out- and in-patients, chronic and acute, with and without paranoid symptoms) show an attentional bias toward threat. Additionally, although previous research had identified the threat-related bias as a state marker of persecutory delusions (Green et al., 2003; Phillips et al., 2000), we did not find an association between positive symptoms and an avoidance of threatening material. Thus, the findings support that the threat-related bias in SZ may be independent of psychotic symptoms severity. We acknowledge, however, that perhaps complex scenes presented in competition during only 3 s may not be enough to overwhelm patients and, thus, to evoke an avoidance pattern that can be modulated by symptomatology. In addition, the exploratory analysis revealed that individuals with SZ showed an association between the depressive symptoms' intensity and the attentional maintenance bias toward threat (i.e., percentage of total fixations to threat), but this association was not found in the control group. Previous eye-tracking studies have demonstrated an attentional bias to threat in depressed bipolar individuals (García-Blanco et al, 2014, 2015), but it has not been the case in monopolar depression (Suslow et al., 2020). This may suggest that the association between the threat-related bias and depressive symptoms is restricted to the psychotic spectrum. In this regard, Bentall et al. (2001) suggested that depressive symptoms are related to threat-related external attributions and attentional biases toward threatening information to protect the self-stem of individuals with SZ.

There are several limitations to the current study. First, this experiment was designed with an ecological setting, assessing a heterogeneous sample and using complex scenes to increase the generalization of findings, but it may also decrease experimental control. Second, as expected, we found a discrepancy in the educational level between the groups since SZ is a disorder that emerges in early adulthood. Although we excluded patients with intellectual disabilities, it remains unclear if neurocognitive functioning could have influenced the eye-tracking outcomes. However, our interest here was to examine how emotional contents modulate the attentional patterns, rather than assessing overall attentional performance, so these variables are less transcendent. Finally, although this experiment suggests that attentional biases toward threat may be a cognitive trait marker in SZ, this was a cross-sectional study. Further longitudinal research is needed to evaluate temporal stability and to ensure that it is not related to clinical features.

To conclude, this experiment reveals an attentional engagement and maintenance bias toward threatening information in SZ. The findings offer empirical support to affective-information processing models stating that threatening information is preferably attended in the disorder, which may confer psychological vulnerability to develop psychosis (Garety et al., 2001; Green and Phillips, 2004; Underwood et al., 2016). Beyond its theoretical implications, the study provides new avenues for further experimentation on specific threat processing in SZ, which can shed light on the pathological pathways of the disorder. Furthermore, the findings have the potential to improve psychological interventions focused on social functioning, such as attentional bias modification paradigms and cognitive-behavior interventions managing maladaptive schemas related to threat-processing (Blackwood et al., 2001).

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## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## References

American Psychiatric Association, 2013. DSM-5. Am. J. Psychiatr. https://doi.org/10.1176/appi.books.9780890425596.744053.

Arguedas, D., Green, M.J., Langdon, R., Coltheart, M., 2006. Selective attention to threatening faces in delusion-prone individuals. Cognit. Neuropsychiatry 11, 557–575. https://doi.org/10.1080/13546800500305179.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M.J., van IJzendoorn, M. H., 2007. Threat-related attentional bias in anxious and nonanxious individuals: a meta-analytic study. Psychol. Bull. 133, 1–24. https://doi.org/10.1037/0033-2909.133.1.1.

Barnes, L.L.B., Harp, D., Jung, W.S., 2002. Reliability generalization of scores on the Spielberger state-trait anxiety inventory. Educ. Psychol. Meas. 62, 603–618. https://doi.org/10.1177/0013164402062004005.
Beck, A., Rector, N.A., 2005. Cognitive approaches to schizophrenia: theory and therapy. Annu. Rev. Clin. Psychol. 1, 577–606.
Beck, A., Rush, J., Shaw, B., Emery, G., 1979. Cognitive Therapy for Depression. Guilford, New York.
Beck, A., Steer, R., Brown, G., 1996. Beck Depression Inventory-II. San Antonio.
Bentall, R., Corcoran, R., Howard, R., Blackwood, N., Kinderman, P., 2001. Persecutory Delusions: A Review and Theoretical Integration 21, pp. 1143–1192. https://doi.org/10.1016/S0272-7358(01)00106-4.
Bentall, R., Fernyhough, C., Morrison, A.P., Lewis, S., Corcoran, R., 2007. Prospects for a cognitive-developmental account of psychotic experiences. Br. J. Clin. Psychol. https://doi.org/10.1348/014466506X123011.
Bentall, R., Kaney, S., 1989. Content specific information processing and persecutory delusions: an investigation using the emotional Stroop test. Br. J. Med. Psychol. 62 (Pt 4), 355–364.
Bentall, R.P., 1992. Reconstructing Schizophrenia. Routledge.
Besnier, N., Kaladjian, A., Mazzola-Pomietto, P., Adida, M., Fakra, E., Jeanningros, R., Azorin, J.-M., 2011. Differential responses to emotional interference in paranoid schizophrenia and bipolar mania. Psychopathology 44, 1–11.
Blackwood, N., Howard, R., Bentall, R., Murray, R., 2001. Cognitive neuropsychiatric models of persecutory delusions. Am. J. Psychiatr. https://doi.org/10.1176/appi.ajp.158.4.527.
Cohen, A.S., Najolia, G.M., Brown, L.A., Minor, K.S., 2011. The state-trait disjunction of anhedonia in schizophrenia: potential affective, cognitive and social-based mechanisms. Clin. Psychol. Rev. https://doi.org/10.1016/j.cpr.2010.11.001.
Demily, C., Attala, N., Fouldrin, G., Czernecki, V., Menard, J.-F., Lamy, S., Dubois, B., Thibaut, F., Ménard, J.-F., Lamy, S., Dubois, B., Thibaut, F., 2010. The Emotional Stroop task: a comparison between schizophrenic subjects and controls. Eur. Psychiatr. 25, 75–79.
Dodgson, G., Gordon, S., 2009. Avoiding false negatives: are some auditory hallucinations an evolved design flaw? Behav. Cognit. Psychother. 37, 325–334.
Feroz, F.S., Leicht, G., Rauh, J., Mulert, C., 2019. 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. 32, 161–177. https://doi.org/10.1007/s10548-018-0677-0.
First, M.B., 2015. Structured clinical interview for the *DSM* (SCID). In: The Encyclopedia of Clinical Psychology. John Wiley & Sons, Inc., Hoboken, NJ, USA, pp. 1–6. https://doi.org/10.1002/9781118625392.wbecp351.
Fletcher-Watson, S., Leekam, S.R., Benson, V., Frank, M.C., Findlay, J.M., 2009. Eye-movements reveal attention to social information in autism spectrum disorder. Neuropsychologia 47, 248–257. https://doi.org/10.1016/j.neuropsychologia.2008.07.016.
Freeman, D., Garety, P.A., Kuipers, E., Fowler, D., Bebbington, P.E., 2002. A cognitive model of persecutory delusions. Br. J. Clin. Psychol. 41, 331–347.
García-Blanco, A., Salmerón, L., Perea, M., 2015. Attentional capture by emotional scenes across episodes in bipolar disorder: evidence from a free-viewing task. Biol. Psychol. 108, 36–42. https://doi.org/10.1016/j.biopsycho.2015.03.010.
García-Blanco, A., Salmerón, L., Perea, M., Livianos, L., 2014. Attentional biases toward emotional images in the different episodes of bipolar disorder: an eye-tracking study. Psychiatr. Res. 215, 628–633. https://doi.org/10.1016/j.psychres.2013.12.039.
Garety, P., Kuipers, E., Fowler, D., Freeman, D., Bebbington, P., 2001. A cognitive model of the positive symptoms of psychosis. Psychol. Med. 31, 189–195.
Green, M.J., Phillips, M.L., 2004. Social threat perception and the evolution of paranoia. Neurosci. Biobehav. Rev. 28, 333–342.
Green, M.J., Williams, L., Davidson, D., 2001. Processing of threat-related affect is delayed in delusion-prone individuals. Br. J. Clin. Psychol. 40, 157–165. https://doi.org/10.1348/014466501163607.
Green, M.J., Williams, L.M., Davidson, D., 2003. Visual scanpaths to threat-related faces in deluded schizophrenia. Psychiatr. Res. 119, 271–285. https://doi.org/10.1016/S0165-1781%2803%2900129-X.
Holm, S., 1979. A simple sequentially rejective multiple test procedure. Scand. J. Stat.
Jang, S.-K., Kim, S., Kim, C.-Y., Lee, H.-S., Choi, K.-H., 2016. Attentional processing of emotional faces in schizophrenia: evidence from eye tracking. J. Abnorm. Psychol. 125, 894–906. https://doi.org/10.1037/abn0000198.
Kay, S., Fiszbein, A., Opler, L., 1987. The positive and negative syndrome scale (PANSS) for schizophrenia. Schizophr. Bull. 13, 261–276.
Kellough, J.L., Beevers, C.G., Ellis, A.J., Wells, T.T., 2008. Time course of selective attention in clinically depressed young adults: an eye tracking study. Behav. Res. Ther. 46, 1238–1243. https://doi.org/10.1016/j.brat.2008.07.004.
Lang, P.J., Bradley, M.M., Cuthbert, B.N., 2005. International Affective Picture System (IAPS): Affective Ratings of Pictures and Instruction Manual (Technical Report A-6). University of Florida, Gainesville, FL.
Li, X.-B., Jiang, W.-L., Wen, Y.-J., Wang, C.-M., Tian, Q., Fan, Y., Yang, H.-B., Wang, C.-Y., 2020. The attenuated visual scanpaths of patients with schizophrenia whilst recognizing emotional facial expressions are worsened in natural social scenes. Schizophr. Res. 220, 155–163. https://doi.org/10.1016/j.schres.2020.03.040.
Menyhart, O., Weltz, B., Győrffy, B., 2021. MultipleTesting.com: a tool for life science researchers for multiple hypothesis testing correction. PloS One 16, e0245824. https://doi.org/10.1371/journal.pone.0245824.
Moritz, S., Steffen, L., 2007. Attention bias for paranoia-relevant visual stimuli in schizophrenia. Cognit. Neuropsychiatry 12, 381–390. https://doi.org/10.1080/13546800601119982.
Navalón, P., Serrano, E., Almansa, B., Perea, M., Benavent, P., Domínguez, A., Sierra, P., Cañada, Y., García-Blanco, A., 2021. Attentional biases to emotional scenes in schizophrenia: an eye-tracking study. Biol. Psychol. 160 https://doi.org/10.1016/j.biopsycho.2021.108045.
Nikolaides, A., Miess, S., Auvera, I., Müller, R., Klosterkötter, J., Ruhrmann, S., 2016. Restricted attention to social cues in schizophrenia patients. Eur. Arch. Psychiatr. Clin. Neurosci. 266, 649–661. https://doi.org/10.1007/s00406-016-0705-6.
Nummenmaa, L., Hyönä, J., Calvo, M.G., 2006. Eye movement assessment of selective attentional capture by emotional pictures. Emotion 6, 257–268. https://doi.org/10.1037/1528-3542.6.2.257.
Peralta, V., Cuesta, M.J., 1994. Psychometric properties of the positive and negative syndrome scale (PANSS) in schizophrenia. Psychiatr. Res. 53, 31–40. https://doi.org/10.1016/0165-1781(94)90093-0.
Phillips, M.L., Senior, C., David, A.S., 2000. Perception of threat in schizophrenics with persecutory delusions: an investigation using visual scan paths. Psychol. Med. 30, 157–167.
Quirk, S.W., Strauss, M.E., 2001. Visual exploration of emotion eliciting images by patients with schizophrenia. J. Nerv. Ment. Dis. 189, 757–765. https://doi.org/10.1097/00005053-200111000-00005.
Savulich, G., Shergill, S., Yiend, J., 2012. Biased cognition in psychosis [WWW Document]. J. Exp. Psychopathol.
Spielberger, C.D., Gorsuch, R.L., Lushene, R., Vagg, P.R., Jacobs, G.A., 1983. Manual for the State-Trait Anxiety Inventory. Palo Alto, CA.
Strauss, G.P., Allen, D.N., Duke, L.A., Ross, S.A., Schwartz, J., 2008. Automatic affective processing impairments in patients with deficit syndrome schizophrenia. Schizophr. Res. 102, 76–87.
Strauss, G.P., Kappenman, E.S., Culbreth, A.J., Catalano, L.T., Ossenfort, K.L., Lee, B.G., Gold, J.M., 2015. Emotion regulation abnormalities in schizophrenia: directed attention strategies fail to decrease the neurophysiological response to unpleasant stimuli. J. Abnorm. Psychol. 124, 288–301.
Suslow, T., Hußlack, A., Kersting, A., Bodenschatz, C.M., 2020. Attentional biases to emotional information in clinical depression: a systematic and meta-analytic review of eye tracking findings. J. Affect. Disord. 274, 632–642. https://doi.org/10.1016/J.JAD.2020.05.140.
Taylor, J.L., John, C.H., 2004. Attentional and memory bias in persecutory delusions and depression. Psychopathology 37, 233–241. https://doi.org/10.1159/000080719.
Underwood, R., Kumari, V., Emmanuelle, P., 2016. Cognitive and neural models of threat appraisal in psychosis: a theoretical integration. Psychiatr. Res. 239, 131–138. https://doi.org/10.1016/j.psychres.2016.03.016.
von der Malsburg, T., Angele, B., 2017. False positives and other statistical errors in standard analyses of eye movements in reading. J. Mem. Lang. 94, 119–133. https://doi.org/10.1016/j.jml.2016.10.003.
Wang, Y.-P., Gorenstein, C., 2013. Psychometric properties of the Beck depression inventory-II: a comprehensive review. Rev. Bras. Psiquiatr. 35, 416–431. https://doi.org/10.1590/1516-4446-2012-1048.