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Research Paper

# Associative learning and facial expression recognition in schizophrenic patients: Effects of social presence

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A B S T R A C T

Schizophrenia (SCZ) is a psychiatric disorder that alters both general and social cognition. However, the exact mechanisms that are altered remain to be elucidated. In this study, we investigated associative learning (AL) and facial expression recognition (FER) in the same patients, using emotional expressions and abstract images. Our main aim was to investigate how these cognitive abilities are affected by SCZ and to assess the role of mere social presence, a factor that has not been considered before. The study compared the behavioral performance of 60 treated outpatients with SCZ and 103 demographically matched healthy volunteers. In the AL task, participants had to associate abstract images or facial expressions with key presses, guided by feedback on each trial. In the FER task, they had to report whether two successively presented facial expressions were the same or different. All participants performed the two tasks under two social context conditions: alone or in the presence of a passive but attentive audience. The results showed a severe learning impairment in patients compared to controls, with a slight advantage for facial expressions compared to abstract images, and a gender-dependent effect of social presence. In contrast, facial expression recognition was partially spared in patients and facilitated by social presence. We conclude that cognitive abilities are impaired in patients with SCZ, but their investigation needs to take into account the social context in which they are assessed.

## 1. Introduction

Schizophrenia (SCZ) is a complex disorder that affects a wide range of brain functions in both domain-general and in social cognition (Bediou et al., 2012; Bortolon et al., 2015; Dickinson et al., 2004; Green et al., 2015). Cognitive deficits have been demonstrated in patients with SCZ using a variety of paradigms (Betz et al., 2019; Dickinson et al., 2004; Gold et al., 2008; Krabbendam and Jolles, 2003; Murray et al., 2017; Nuechterlein et al., 2004; Prentice et al., 2008; Waltz and Gold, 2007). In this study, we focus on two cognitive functions that are crucial for everyday activities: associative learning (AL) and facial expression recognition (FER). Associative learning, also referred to as arbitrary sensorimotor or reinforcement learning (Wise et al., 1996; Wise and Murray, 2000), is a fundamental cognitive ability that allows humans and non-human animals to link the consequences of actions and behaviors to their environmental context, and thus adapt to changing environments. Although several studies have previously shown impaired AL in SCZ, the results have been inconsistent across studies (Chang et al., 2016; Collins et al., 2017; Gold et al., 2008, 2009), and the discrepancies have been discussed in light of differences in symptom severity between patients and across studies, as well as a variety of other factors (Collins et al., 2014). FER, on the other hand, has been extensively studied because of its key role in social cognition and behavior, the impairment of which is a hallmark of SCZ (Penn et al., 2008; Ziv et al., 2011). Understandably, there has been a great deal of interest in exploring social cognitive deficits in individuals with SCZ over the past few decades, and it is well established that FER is severely impaired (Green et al., 2015; Kohler et al., 2010; Marwick and Hall, 2008; Penn et al., 2008; Savla et al., 2013). However, not all studies found the same deficits in patients, possibly depending on the tasks used or other factors such as disease severity and medication (Gold et al., 2008; Montagnese et al., 2020).

Despite a very high interest in the impact of SCZ on social cognition, published studies to date have not addressed potential effects of the social environment, which may play a critical role when assessing cognitive and behavioral performance. Indeed, social psychology research has shown that even small variations in the social context, such as the location of the investigator relative to the participant, whether

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they were visible/invisible to the participant, if and how they interacted with the subject during the test session, can have profound effects on performance (Huguet et al., 1999). This phenomenon, known as social facilitation/impairment caused by the mere presence of others, without any overt interaction with the subject, has been studied by social psychologists for over a century, and has been reported using a variety of tasks in humans and non-human animals (Bennani et al., 2023; Bond and Titus, 1983; Demolliens et al., 2017; Guerin, 1986; Huguet et al., 1999; Huguet et al., 2014; Zajonc, 1965). Typically, mere presence of others enhances performance on easy, well-mastered tasks, and impairs performance on difficult not yet mastered tasks, presumably through attentional mechanisms (Bond and Titus, 1983; Sanders et al., 1978). To the extent that schizophrenia alters social and domain-general cognition, including executive functions (Chieffi et al., 2015; Krabbendam and Jolles, 2003; Luck et al., 2019; Morris et al., 2013; Nuechterlein et al., 2004), we hypothesized that sensitivity to and awareness of the presence of others' would be impaired.

## 2. Materials and methods

### 2.1. Participants

The study included 60 patients (18 to 45 years old; 30 females), diagnosed with schizophrenia according to DSM-IV criteria, with no history of neurological disorders or major trauma to the central nervous system. The patients were recruited at the Ibn Rochd University Psychiatric Center of Casablanca (Morocco) and were under neuroleptic or antipsychotic treatment and in remission. All patients were in a stable psychopathological state, based on the Positive and Negative Syndromes Scale (Kay et al., 1987). A group of healthy volunteers (N = 103; 53 females), matched for age and sex to the patient group, was recruited from the general population of the Casablanca region. Exclusion criteria were the presence of a neurological or psychiatric disease or a first-degree neurological or psychiatric family history. Sociodemographic data were collected using a questionnaire on health status and toxic substance use, and anxiety levels were assessed using an Arabic version of the Liebowitz Social Anxiety Scale (LSAS). All participants had normal or corrected-to-normal vision and gave written consent to participate in this study, in accordance with the Helsinki Declaration. The study was approved by the local ethics committee of the Casablanca Faculty of Medicine and Pharmacy (#23/18).

### 2.2. Stimuli and procedure

Four faces, each with one of three emotional expressions (happy, neutral, sad) and three homemade abstract images were used (Fig. 1). Behavioral testing was carried out in a quiet room and the experiment was conducted on a laptop computer using PsychoPy (Peirce et al., 2019). Participants sat in front of the laptop and performed two tasks with their right hand: an associative learning (AL) task, and a facial expression recognition (FER) task.

In the AL task (Fig. 2a), participants were shown an image or a facial expression and were asked to find, by trial-and-error, which of three arrow keys on the computer keyboard corresponded to each. Immediately after pressing a key, they received visual feedback indicating whether their response was correct (green circle), or incorrect (red circle). Each image/facial expression was presented 20 times, with a total of 120 trials per learning session. In the FER task (Fig. 2c), participants were asked to report whether the facial expressions of two consecutive faces were the same or different, ignoring the identity of the faces. If the expressions were the same, the participant had to press the "Y" key, if they were different the participant had to press the "N" key. Because ignoring the identity of faces requires inhibitory control, different trial types were defined by combinations of facial expressions and faces: same expressions / same faces (SESF, low cognitive demands), same expressions / different faces (SEDF; high demands), different expressions / same faces (DESF; intermediate). In the DESF trials, correct performance would require reaching the decision that the facial expressions were different, and the success rate would assess patients' spared recognition abilities.

Participants were tested in two sessions of 20 min each. In one session, they were alone in the test room (Alone condition); in the other, a person was present (Presence condition), sitting face to face with the subject (Fig. 2d). To control for order effects, the sequence was Alone + Presence for half of the participants (patients and controls), and Presence + Alone for the other half.

### 2.3. Data collection and analysis

Data were processed to extract reaction times (RTs) and the

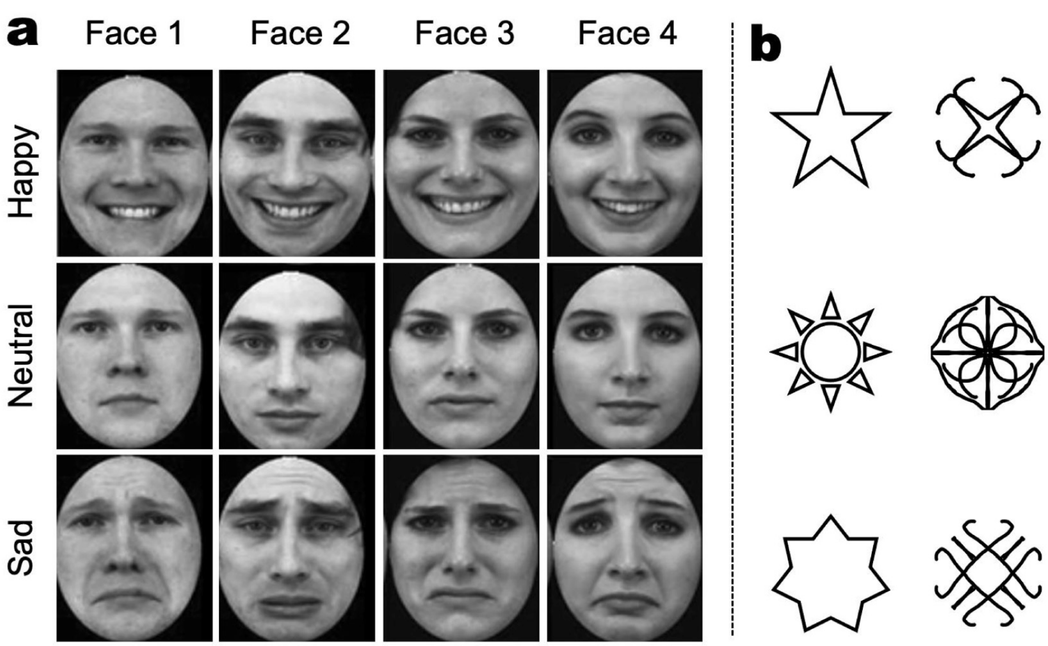



**Fig. 1.** Stimuli. *(a)* Faces extracted from the KDEF (Calvo et al., 2008). *(b)* Home-made drawings used for abstract images.

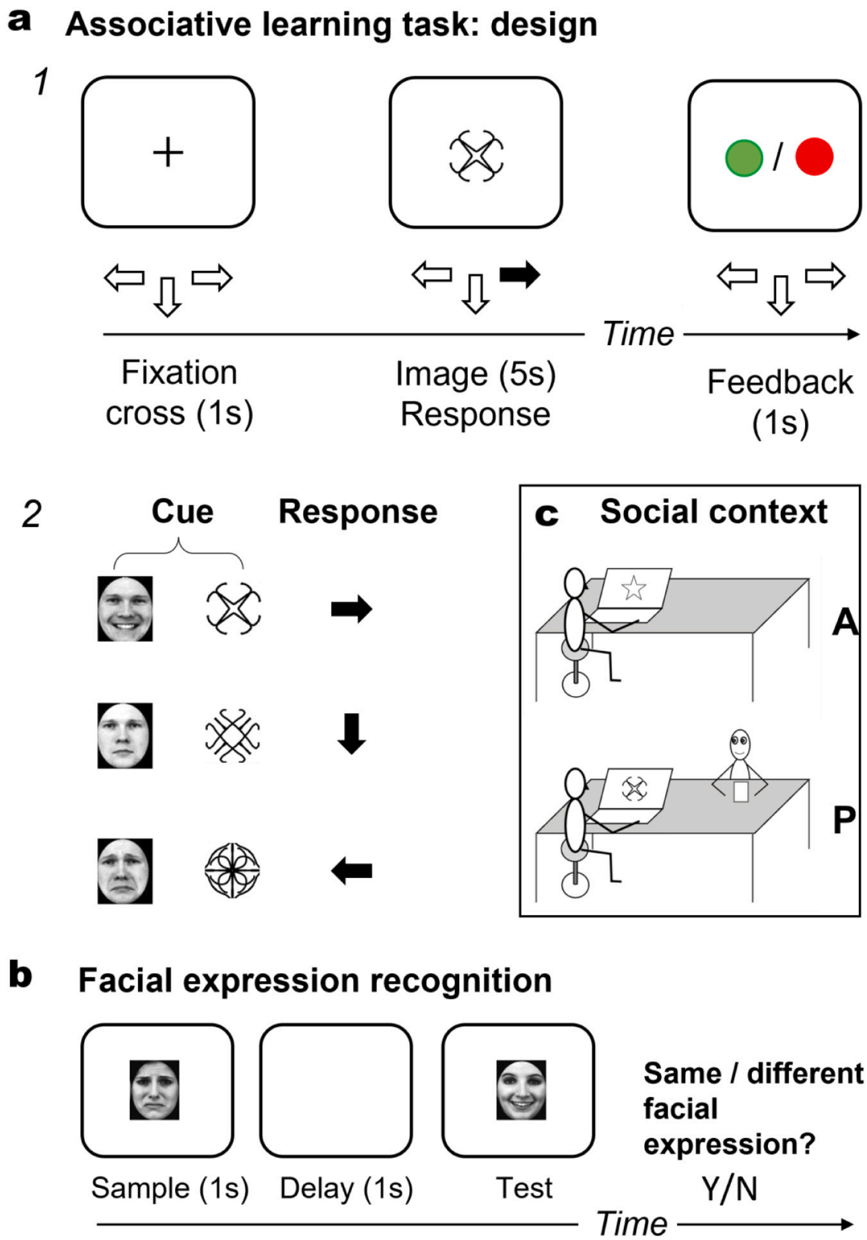



**Fig. 2.** Experimental design. (a1) Associative learning task. The panels depict the computer screen at specific events during a typical trial. Below each panel, the three arrows represent the arrow keys of the computer keyboard. Time flows from left to right. The trial starts with a fixation cross displayed for 1 s, followed by an image which lasts for up to 5 s. The subject presses one key (in black) to indicate their choice of which key is associated with this image. If correct, a green circle appeared (positive feedback), if incorrect, a red circle is displayed (error feedback). (a2) Associations to be discovered by the participant, between facial expressions (left) or abstract images (right). (b) Facial expression recognition task. On each trial, two facial expressions (sample and test) are displayed, with an interval of 1 s. The participant was instructed to press the key "Y" if they were the same expressions, the "N" key if they were different. (c) Social context. Participants performed the two tasks under two social conditions: alone (A) or in presence (P) of another person.

percentage of correct responses (PCR). Behavioral measures were extracted for each participant by task (AL, FER) and session (Alone, Presence), and combined with sociodemographic (sex, age, education level) and clinical data (PANSS, SLAS scores) for statistical analyses using the JASP statistics software (JASP).

For the learning task, the session was divided into three learning phases (Fig. 3): early (first 7 trials), middle (next 7 trials) and late (last 6 trials). Statistical analyses were performed to examine PCR (dependent variable) changes at different learning stages, and investigate the effects of stimulus type, social context, and sex. Contribution of task repetition vs. social presence to the changes in performance was quantified with the following index: Task repetition effect: (A2-P1)/(A2 + P1); Social presence effect: (P2-A1)/(P2 + A1), where A and P represent the PCR for the Alone and Presence conditions, respectively, and 1 and 2 the order in which they occurred. Finally, for the FER task, the mean PCR across all trials was computed for each session (Alone, Presence), and for different trial types (SESF, DESF, SEDF). Analyses sought to examine the variations in PCR depending on social context, stimulus type and sex in patients, compared to controls.

## 3. Results

Table 1 summarizes the participants' demographics, clinical scores and gross behavioral performance. Overall, patients had a significantly lower levels of education ($p = .006$), lower avoidance scores ($p < .001$) and performance ($p < .001$), than controls.

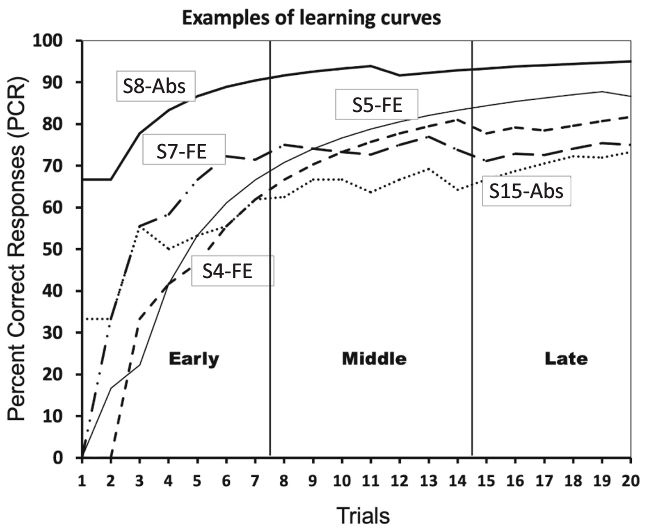



**Fig. 3.** Associative learning task. Examples of learning curves. The percentage of correct responses (PCR, vertical axis) is shown for 5 subjects for either abstract images (Abs) or facial expressions (FE), as a function of trials 1–20). At each trial, the PCR is obtained by dividing the number of correct trials made by the total number of trials. Three learning stages are arbitrarily defined: early (first 7 trials), middle (next 7 trials) and late (last 6 trials).

**Table 1**
Summary table of demographics, clinical scores and gross behavioral data. From left to right, average values (mean; standard deviation, std.; minimum and maximum values; p value for group comparison) are shown for patients (SCZ) and healthy controls (CTR), for Age, Education, Liebowitz anxiety (An. Score) and avoidance (Av. Score) scores, PANSS, and overall percentage correct responses (PCR) and reaction times (RT) for associative learning task (PCR-AL) and facial expression recognition (PCR-FER, RT-FER). Simple main effect analysis of Differences of group means were tested using a simple ANOVA.

| N=60 (SCZ)<br>N=163 (CTR) | | | Mean | Std | Min | Max | P value |
|---|---|---|---|---|---|---|---|
| *Demographics* | **Age** | SCZ | 30,60 | 7,00 | 19,00 | 45,00 | .501 |
| | | CTR | 29,00 | 7,20 | 18,00 | 45,00 | |
| | **Education** | SCZ | 2,50 | 1,91 | 0,00 | 7,00 | ***.006*** |
| | | CTR | 4,10 | 2,10 | 0,00 | 7,00 | |
| *Clinical scores* | **Anxiety Score** | SCZ | 20,10 | 9,55 | 0,00 | 37,00 | .071 |
| | | CTR | 24,50 | 11,60 | 3,00 | 54,00 | |
| | **Avoidance Score** | SCZ | 15,47 | 9,50 | 0,00 | 32,00 | ***<.001*** |
| | | CTR | 28,70 | 12,70 | 7,00 | 59,00 | |
| | **PANSS** | SCZ | 40,07 | 12,31 | 18,00 | 62,00 | NA |
| *Behaviour* | **AL (PCR)** | SCZ | 32,00 | 16,30 | 7,40 | 82,01 | ***<.001*** |
| | | CTR | 63,30 | 16,90 | 3,00 | 92,60 | |
| | **FER (PCR)** | SCZ | 66,16 | 16,30 | 32,29 | 95,83 | ***<.001*** |
| | | CTR | 80,84 | 12,70 | 30,21 | 96,88 | |
| | **FER (RT)** | SCZ | 1129,30 | 303,30 | 506,50 | 1783,85 | ***<.001*** |
| | | CTR | 917,94 | 211,55 | 409,43 | 1400,33 | |

### 3.1. Severely impaired learning in patients

Healthy controls learned to associate images and facial expressions with key presses following a typical learning pattern, characterized by a steep increase in performance in the early stages (first 14 trials) and a slower change in the later stage (Figs. 3 and 4a). In contrast, patients showed little improvement throughout the session. However, both controls and patients learned better with facial expressions than with abstract images (Fig. 4b), and a simple main effects analysis showed a significant effect of stimulus type. Statistical analysis using a repeated measures ANOVA with stimulus type (images, emotions) and learning level (early, middle, late) as within-subject factors and group (CTR, SCZ) and sex (F, M) as between-subject factors, revealed significant main effects of stimulus type ($F_{(1,77)} = 29.181$; $p < .001$; $n_p^2 = 0.275$), learning level ($F_{(2,77)} = 85.520$; $p < .001$; $n_p^2 = 0.526$), and group ($F_{(1,77)} = 97.241$; $p < .001$; $n_p^2 = 0.558$). In addition, there were significant interactions between stimulus type and sex ($F_{(1,77)} = 14.072$; $p < .001$; $n_p^2 = 0.155$), learning level and group ($F_{(2,77)} = 45.828$; $p < .001$; $n_p^2 = 0.373$), and stimulus type, learning level and group ($F_{(2,77)} = 6.396$; $p = .002$; $n_p^2 = 0.077$). Sex differences were found in both controls and patients, with important group differences: in controls, females learned better with abstract images than with facial expressions ($p < .001$), whereas the opposite was found for males. In patients, only males learned with facial expressions ($p = .007$), and neither males nor females learned with images ($p > .089$).

### 3.2. Partially preserved facial expression recognition

Facial expression recognition was also impaired in patients, compared to controls. However, although the main effect of group was highly significant ($F_{(1,161)} = 48.985$; $p < .001$; $n_p^2 = 0.233$), recognition capacities depended on the cognitive load. As shown in Fig. 5, the performance was lowest on high load trials (DESF), highest on low load (SESF) and intermediate on DESF trials. Correct response on the latter indicates that the subject reported that the two facial expressions were different, despite identical faces. The success rate in patients was around 70 % on these trials.

### 3.3. Social modulation of performance

Fig. 6 shows that social presence affected performance in both controls and patients, but the effects differed depending on the task. In the AL task, performance was impaired by social presence in controls (simple main effect, $p = .034$) but was not affected in patients ($p = .848$). However, a repeated measures ANOVA in patients revealed a significant 3-factor interaction between social context, stimulus type and sex ($F_{(1,58)} = 19.994$; $p < .001$; $n_p^2 = 0.256$). Fig. 6b illustrates this result, showing that social presence impaired learning with abstract images for females ($F_{(1,56)} = 6.940$; $p = .014$), whereas it enhanced learning for males ($F_{(1,56)} = 13.567$; $p < .001$). This pattern was reversed for facial expressions, but the differences between social conditions were not statistically significance (females, $p = .115$; males, $p = .143$).

In the FER task, social presence enhanced performance in patients ($p = .040$) but had no effect in controls ($p = .650$). Repeated measures ANOVA with stimulus type (SEDF, DESF, SESF) and social context (Alone, Presence) as within-subject factors, and group (CTR, SCZ) as a between-subjects factor, revealed significant main effects of stimulus type ($F_{(2,322)} = 62.304$; $p < .001$; $n_p^2 = 0.279$) and group ($F_{(1,161)} = 65.795$; $p < .001$; $n_p^2 = 0.290$), as well as a 2-factor interaction between stimulus type and group ($F_{(2,322)} = 7.240$; $p < .001$; $n_p^2 = 0.043$).

### 3.4. Task repetition versus social context

Further analyses revealed that task repetition contributed to changes in performance. In general, when participants (patients and controls) performed the task for the second time, their performance improved.

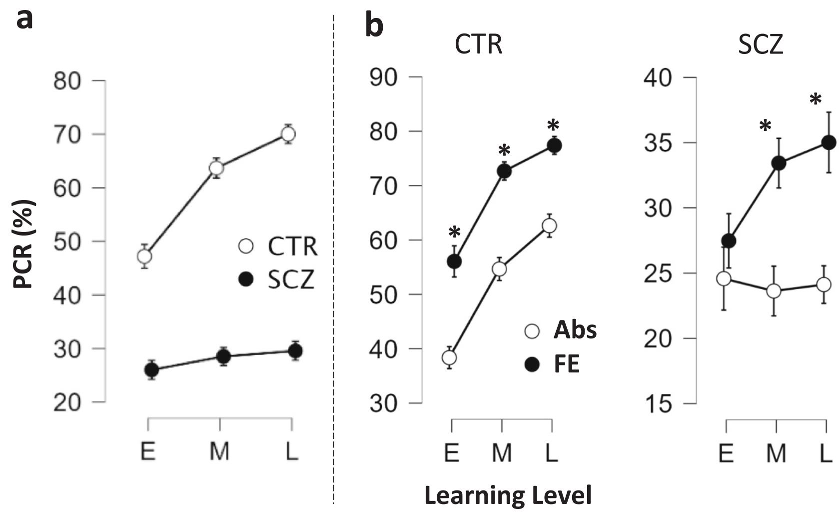



**Fig. 4.** Associative learning capacities in healthy controls (CTR) and in patients (SCZ). (a) Comparison of group average performance between healthy subjects (filled symbol) and patients (open symbol), under the alone condition and in the AP order. The PCR is shown for each of the three learning levels (E, early; M, middle; L, late). Open and filled symbols represent group mean PCR, vertical bars depict the standard error. (b) Comparison of learning across stimulus types (Abs, abstract images; FE, facial expressions) for each group. (*) significant differences at p < .05.

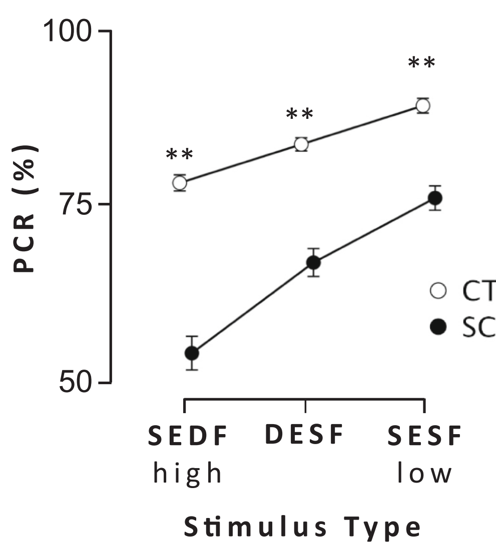



**Fig. 5.** Facial expression recognition. Comparison of performance between healthy controls and SCZ patients for the three stimulus types: SEDF, same expressions / different faces (high cognitive load); DESF, different expressions / same faces; SESF, same expressions / same faces (low cognitive load). (**) Significant at p < .001.

However, when social presence was administered second, the net effect was negative for controls (consistent with social impairment, see above), but was positive for patients specifically for abstract images (Fig. 7).

## 4. Discussion

We reported a severe learning impairment in SCZ patients compared to controls, with more severe deficits for abstract images than for facial expressions. Social presence impaired learning in healthy subjects, but had both facilitatory and inhibitory effects in patients, depending on sex and stimulus type. Although patients were impaired in emotion recognition, their abilities were partially preserved under low cognitive demands, and were further facilitated by social presence. We discuss these findings to highlight the potential benefits of using emotional cues, and social context when dealing with SCZ patients.

### 4.1. Impaired learning, but preserved emotion processing

Previous studies have reported deficits in different learning types including reinforcement and implicit learning (Cicero et al., 2014; Horan et al., 2008; Murray et al., 2017; Waltz and Gold, 2007), but not all studies found learning deficits in SCZ patients. Gold et al. (2008) proposed a distinction between impaired learning based on trial-to-trial feedback, and preserved long-term learning where feedback information is integrated over multiple trials. Failure to learn in trial-to-trial paradigms has been linked to functional changes in the prefrontal regions involved in the processing of the value of outcomes (Bradfield et al., 2015; Rudebeck et al., 2017), whereas preserved long-term learning would rely on the basal ganglia, known to be critical for habit learning (Brovelli et al., 2008; Yin and Knowlton, 2006).

Our results confirm that SCZ patients are unable to learn visuomotor associations based on trial-to-trial feedback and bring new insights into the complexity of the interactions between various factors. First, the deficits were more severe when patients had to associate abstract images with motor responses than with facial expressions. Second, we provide additional evidence for sex differences, showing more severe deficits in female than in male patients. These deficits are unlikely due to altered emotional processes, as learning was better with emotional cues, and facial expression recognition abilities were relatively spared. Alternatively, learning deficits may be the consequence of impaired general sensorimotor, cognitive and affective functions (Gold et al., 2008; Ziv et al., 2011). This possibility is not supported by the fact that the patients performed relatively well on the FER task, which requires exactly these functions. Rather, our results strengthen the possibility that the learning impairment is due to failure in learning-related mechanisms (Gold et al., 2008, 2009), such as reward/error processes, in relation with dysregulation of the dopaminergic system in schizophrenia (Heinz et al., 2019; Heinz and Schlagenhauf, 2010; Kapur and Mamo, 2003; Millard et al., 2022; Schultz et al., 1997). Interestingly, task repetition enhanced the performance of patients, consistent with the proposal that long-term learning may be preserved (Gold et al., 2008).

Numerous studies have previously reported that emotion processing and facial expression recognition are impaired in SCZ patients (Barkl et al., 2014; Kohler et al., 2010; Li et al., 2010; Marwick and Hall, 2008; Penn et al., 2008; Tsoi et al., 2008; Ventura et al., 2013). Successful performance on the FER task requires short-term memory storage of the sample facial expression, until the test facial expression appears.

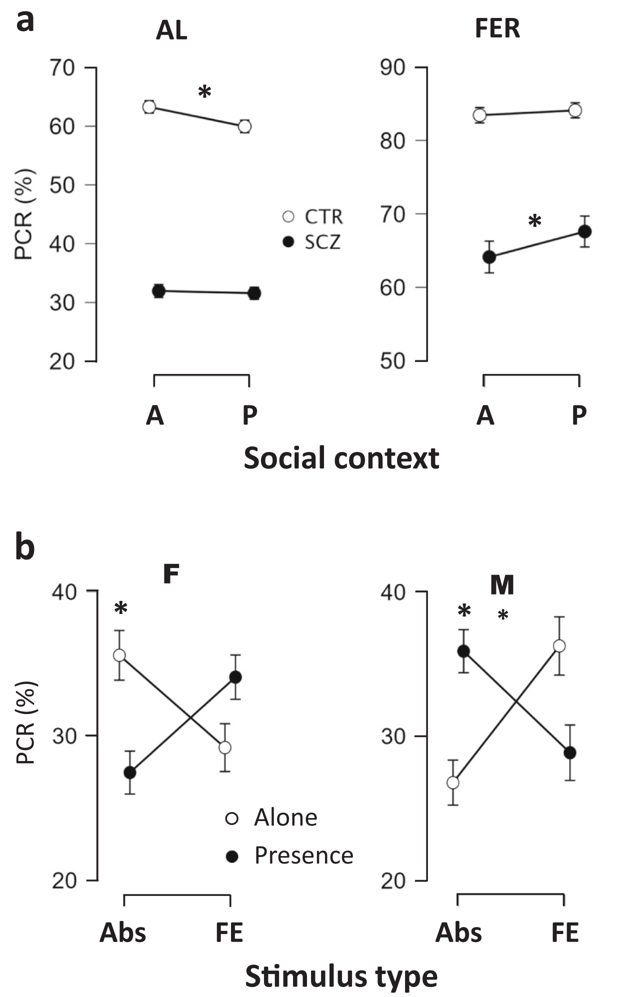


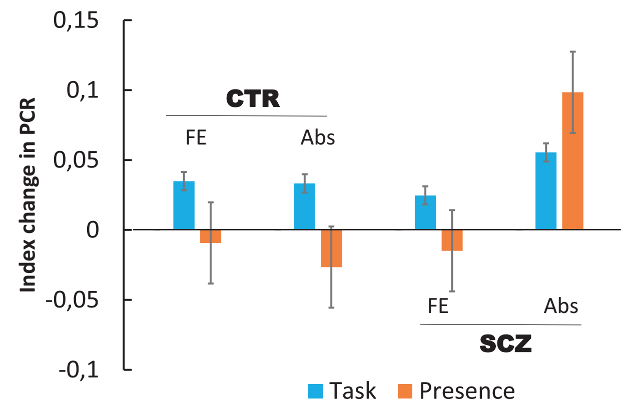

**Fig. 6.** Modulation of learning performance by stimulus type and social context. (a) Comparison of mean performance across social conditions for controls (CTR) and patients (SCZ). The PCR is shown for the two social conditions (A, Alone; P, Presence). (b) Modulation of PCR by social context in female (F) and male (M) patients, for learning with abstract images (Abs) and facial expressions (FE). (*) significant differences at $p < .05$.

Consistent with previous reports showing that both facial expression and working memory are impaired in SCZ (Gold et al., 2008; Horan et al., 2008; Tsoi et al., 2008; Ventura et al., 2013), our results showed significantly impaired performance in patients, compared to controls. Although, on average, patients were able to process facial expressions, they could do so with relatively good accuracy when distracting information was low. Indeed, just like controls, patients were challenged on trials which required focusing attention on the task at hand (compare facial expression), while inhibiting the (automatic) processing of the identity of faces. This incongruence taps into the management of executive attentional resources and shows that patients have difficulty maintaining their attentional focus on the task when cognitive demands are high. This is consistent with attentional deficits reported in schizophrenia patients (for review see (Chieffi et al., 2015; Luck et al., 2019)).

### 4.2. Impaired processing of others' presence

Awareness of the presence of others is a key aspect of social cognition. Typically, in healthy subjects, mere presence enhances cognitive and behavioral performance on easy, well-learned tasks, and impairs performance on difficult tasks (Guerin, 1986; Zajonc, 1965). As expected, using a learning task we found impaired performance in controls under social presence (social impairment). By contrast, patients failed to show a typical pattern of modulations related to mere presence, with rather complex interactions between this factor and two other factors: the type of stimulus used (images, emotions) and sex. On the FER task, however, performance of patients was enhanced by social presence (social facilitation), whereas there was no effect in controls. Although social presence has not been addressed systematically in previous Schizophrenia research, the results of a recent study (Strassnig et al., 2021) suggest that SCZ patients may be insensitive to others' presence. While our findings confirm that the processing of social presence is altered in SCZ, they further suggest that the deficit may be related to their ability to attend to others while focusing on the task, depending on the type of sensory information provided. Furthermore, not only are sex differences in domain-general and social cognition well established in schizophrenia (Häfner, 2003; Seeman, 2022; Ventura et al., 2023; Li et al., 2023), but women and men generally differ in their socio-emotional behavior (Christov-Moore et al., 2014). The present results bring additional evidence for such sex differences and suggest that women and men with SCZ differ in their sensitivity to the presence of others. As social facilitation/impairment phenomena are generally interpreted in relation to the allocation of attentional resources (Bond and Titus, 1983; Huguet et al., 1999; Sanders et al., 1978), these sex differences would lead to differences in how females and males focus their attention on the task at hand (here facial expressions) while attending to the other person present.

In conclusion, we show that SCZ patients are severely impaired in associative learning, but their ability to recognize facial expressions is partially preserved. Patients' performance depended on factors such as the type of stimuli used (abstract vs. emotional cues), the social context and sex. Social cognitive functions are altered to different degrees in female and male SCZ, and consideration of their ability to attend to other social agents may provide new insights.




| Order | 1 | 2 |
|---|---|---|
| Social condition | Alone (A1) | Presence (P2) |
| | Presence (P1) | Alone (A2) |

Index change due to social presence: (P2-A1)/(P2+A1)
Index change due to task repetition: (A2-P1)/(A2+P1)

**Fig. 7.** Contribution of task repetition vs. social presence. An index of change in PCR was calculated for task repetition and for social presence. Change due to task repetition: (A2-P1)/(A2 + P1), vs. social presence (P2-A1)/(P2 + A1), is shown for controls (CTR) and for patients (SCZ), for abstract images (Abs) and facial expressions (FE). A and P, PCR measured in the Alone and Presence condition, respectively, when they occurred first (1) or second (2).

### 4.3. Limitations

The severity of learning deficits may be partly due to task difficulty. In fact, even controls were slow to learn with abstract images, and made on average only 60 % correct responses at the end of the session. Perhaps abstract images were more difficult to discriminate, but the fact that healthy women learned better with abstract images, tends to minimize this potential limitation.

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None.

## CRediT authorship contribution statement

**Khansa Charaf:** Conceptualization, Methodology, Formal analysis, Writing – original draft. **Mohamed Agoub:** Conceptualization, Methodology, Supervision, Project administration. **Driss Boussaoud:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Supervision.

## Declaration of competing interest

The authors declare having no conflict of interest.

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