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Schizophrenia and Emotional Rubbernecking

Teal S. Eich[1] and **Edward E. Smith**[*,1,2,3]

[1]Department of Psychology, Columbia University

[2]Division of Cognitive Neuroscience, New York State Psychiatric Institute

[3]Department of Psychiatry, Columbia University

Abstract

Orienting towards emotionally salient information can be adaptive, as when danger needs to be avoided. Consistent with this idea, research has shown that emotionally valenced information draws attention more than does neutral information in healthy individuals. However, there are times when this tendency is not adaptive, and it may distract the individual from their goals. People with schizophrenia (PSZ), though frequently showing deficits in attentional control, have also been shown to exhibit diminished recognition of and attention to emotional information. In the current study, we investigated how the presentation of emotionally salient information affected performance on a working memory task for PSZ and healthy controls (HC). We found that although hit rates were equal to those of HCs for PSZ, the PSZ made fewer false alarms—resulting in overall better performance-- than the HCs. Deficits in emotional processing in PSZ appear to provide an advantage to them in situations in which salient, emotional information competes with active cognitive goals.

Orienting towards salient information can be adaptive (Anderson & Phelps, 2001; LeDoux, 1996). However, this often automatic, bottom-up process can also be in opposition to one's active cognitive goals: it would be better for people to keep their hands on the wheel and eyes on the road instead of rubbernecking. And yet it is often times impossible to not crane your neck to see the accident on the other side of the highway. In these types of situations, a lack of attention to emotionally loaded stimuli might be adaptive.

Corresponding Author: Teal S. Eich, Department of Psychology, Columbia University, 1190 Amsterdam Avenue, Schermerhorn Hall, 324C, New York, NY 10027, Tse4@columbia.edu, 917-340-4958.

*Edward Smith (Deceased August 17, 2012) was involved in all aspects of the study design. He saw preliminary data analysis indicating the results presented in this manuscript, but passed away before completion of the manuscript.

My PhD mentor, Dr. Edward Smith, was well aware of the voluminous literature demonstrating a broad spectrum of cognitive impairments in people with schizophrenia (PSZ, Chapman & Chapman, 1973; Schaefer, Giangrande, Weinberger & Dickinson, 2013), including deficits in cognitive control (Barch, 2005), memory (Barch, Csernansky, Conturo & Snyder, 2002), attention (Carter, Bizzell, Kim, Bellion, Carpenter, Dichter & Belger, 2010) emotional processing (Gur, McGrath, Chan, Schroeder, Turner, et al., 2002) and reward learning (Gold, Waltz, Prentice, Morris & Heerey, 2008), among other abilities. In fact, we previously explored one of these deficits, and found that PSZ were unable to suppress information that had already entered WM (Smith, Eich, Cebenoyan & Malapani, 2011; Eich, Nee, Insel, Malapani & Smith, under review). However, consistent with his commitment to understanding -- both behaviorally and neurally-- cognitive changes associated with the disease, he also believed that finding and explaining deficiencies was only one way to advance scientific understanding. As such, Ed challenged me, as part of my dissertation, to develop a task in which PSZ would do better than, rather than worse than HCs. In this paper, I attempted to rise to Ed's challenge by creating a novel, modified version of the task in which we found WM deficits previously. This task aimed to exploit a known deficit in schizophrenia, and turn this deficit into an advantage for PSZ.

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Limitations of attentional capacity have long been considered a core cognitive deficit in schizophrenia (Bleuler, 1911/1950; Carter et al., 2010; Gjerde, 1983; Zubin, 1975). A growing body of research suggests that people with schizophrenia (PSZ) show deficits in the ability to use top-down processes to guide attention (Fuller, Luck, Braun, Robinson, McMahon & Gold, 2006). Hahn, Robinson, Kaiser, Harvey, Beck, Leonard, Kappenman, Luck and Gold (2010), for example, showed that when salient (flickering) distractor items were introduced during the encoding phase of a working memory (WM) task, PSZ showed attentional deficits, which led to impaired memory for less salient (non-flickering) target items. When attention was guided by bottom-up, automatic processes, however, as when target items were highly salient, PSZ were able to shift attention and filter less salient distractors effectively (Gold, Fuller, Robinson, McMahon, Braun & Luck, 2006; Luck, Fuller, Braun, Robinson, Summer felt & Gold, 2006). Based on this, it stands to reason that PSZ might show impaired performance relative to healthy controls (HC) in a task in which emotionally salient information must be ignored.

Emotionally valenced information draws attention to a greater extent than does neutral information in HCs (Bradley, 2009; Hajcak, MacNamara & Olvet, 2010; Ohman, Flykt & Esteves, 2001; Egeth & Yantis, 1997). People with SZ, though, show deficits in the processing of and attention to emotional information (Edwards, Jackson & Pattison, 2002a,b; Gur et al., 2002; Loughland, Williams & Gordon, 2002). A recent meta-analysis of studies from 1970-2007 assessing emotion recognition and differentiation in PSZ across a wide range of tasks revealed that PSZ showed marked deficits in the perception of emotional faces, including the recognition of negatively and positively valenced faces. They also showed deficits in the ability to differentiate between emotions of different intensities (Kohler, Walker, Martin, Healey & Moberg, 2010). It follows that the compelling attention-drawing effects of emotional stimuli as compared to neutral stimuli may be smaller for PSZ than for HCs for this reason. Thus, PSZ might do better than HCs in a task in which emotionally salient information must be ignored.

In a previous study we found that PSZ's performance was equal to that of HCs on a cognitive task in which irrelevant perceptual information had to be ignored at the time of encoding, before items had entered WM, even though PSZ were impaired when they were required to suppress the same information once it had entered WM (Smith et al., 2011). In this study, PSZ and HCs were given an instruction to remember either the red or blue words. In the Ignore condition, the instruction cue came before a set of red and blue words. In the Suppress condition, the instruction cue came after the presentation of the colored words. Finally, a test probe was given. The test probe required a positive response if it was one of the words that corresponded to the instruction cue's color. It required a negative response if it was one of the words of the other color, or if it was a new, unpresented word. While there were differences in performance when the PSZ had to suppress information that had already entered WM, our results showed that PSZ performed equivalently to HCs when they had to ignore irrelevant perceptual information, indicating that they did not have deficits in the ability to selectively attend to relevant perceptual information and ignore irrelevant perceptual information that had not yet entered WM.

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In our previous study, we used neutral words and a word-cue instructing participants to attend to either the red or blue words. Here, though, we used emotional stimuli (Happy, Fearful and Neutral faces) and an arrow-cue instructing participants to attend to the left or right. Thus, the valences of the face-stimuli were incidental to the task requirements. In HCs, the presentation of irrelevant but emotional information hurts performance on an unrelated primary task. For example, emotional distractors presented during the WM maintenance phase (the delay interval between presentation of the to-be-remembered information and the test probe) impairs performance (Dolcos, Diaz-Granados, Wang, & McCarthy, 2008). Similarly, Anticevic, Repovs, Corlett and Barch (2011) investigated these effects in PSZ and found that their performance at retrieval was compromised by distracting emotional items introduced during the WM maintenance phase. No study to date, however, has investigated how PSZ would perform on a task in which irrelevant emotional information competed with goal-relevant information at the time of encoding, before information entered WM.

On the one hand, PSZ might perform worse than HCs in a task in which emotional information competes with task-relevant information as they did in Anticevic et al.'s (2011) study: they might not be able to use top-down processes to selectively encode only the relevant information because attention is drawn towards the salient emotional stimuli through bottom-up processes, which would result in impaired performance on the task. A finding such as this would be in line with previous studies showing top-down attentional deficits. On the other hand, it is our hypothesis that in this situation, PSZ might actually benefit from emotional processing deficits. The emotional information might not be seen as salient to PSZ, and therefore they might not attend to or encode this information. This would result in better performance relative to HCs, who are likely to attend to these stimuli because of their salience. The current study aimed to investigate this question.

Methods

Participants

Participants included 25 HCs and 22 PSZ. Data from one additional PSZ was excluded because s/he did not respond to over 20% of experimental trials. The remaining participants were comparable in non-response rates on the task (PSZ averaged 5.05 (standard deviation=6.1), while HCs averaged 4.6 (standard deviation=5.5); this difference was not significant ($t(33)=0.23$).The demographics of the two groups are shown in Table 1, along with clinical ratings and chlorpromazine equivalents (American Psychiatric Association, 1997; Woods, 2003) for the PSZ. There were no significant differences between PSZ and HCs in age ($t(45)=.41$), number of years of education ($t(45)=1.5$), or sex ($t(45)=.09$). HCs, recruited through local and online advertisements, reported being free of current or past psychiatric or neurological illness, alcohol or substance dependency in the last six months, and had not used psychotropic medication, such as antipsychotics or antidepressants, in the last year. People with SZ were stabilized outpatients, recruited through the Lieber Center for Schizophrenia Research and Treatment of the New York State Psychiatric Institute (NYSPI). All patients met DSM-IV criteria for schizophrenia or schizoaffective disorder (First, Spitzer, Gibbon & Williams, 2007). Diagnoses were determined through a diagnostic

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conference that included information from either the Diagnostic Instrument for Genetic Studies (DIGS; Nurnberger, Blehar, Kaufmann, York-Cooler, Simpson et al, 1994) or the Structured Clinical Interview DSM-IV (SCID; First & Pincus, 2002). In addition, the Scale for the Assessment of Positive Symptoms and the Scale for the Assessment of Negative Symptoms (SAPS/SANS; Andreasen & Olsen, 1982), and the Hamilton Depression Scale (Hamilton, 1960) were used to evaluate symptom severity. Ratings for patients were obtained on the day of testing. All PSZ were being treated with atypical antipsychotic medication for at least three months, and had taken the same type and dose of medication for at least one month before the day of testing. All participants were English-speaking.

After the procedure was fully explained to participants, written informed consent was obtained. Capacity to participate in the experiment was also assessed for each PSZ via an interview process with a psychiatrist not related to the study. The research protocol was approved by the Institutional Review Board of the NYSPI and Columbia University.

Materials

The stimuli consisted of 96 pictures of faces from the Karolinska Directed Emotional Faces set (Lundqvist, Flykt & Öhman, 1998). Thirty-two faces (half male, half female) were chosen for each emotion category, Happy, Fearful and Neutral. Faces were masked with an oval.

Procedure

The task is illustrated in Figure 1. People with SZ and HCs completed a novel, emotional version of the Ignore task (modeled upon Smith et al.'s (2011) and Nee & Jonides' (2008, 2009) task).

An arrow pointing either to the left or right was followed by the presentation of two faces. The direction of the arrow was counterbalanced across the experimental trials, and indicated which face the participant should remember: the one on the left side of the screen or the one on the right side of the screen. Trials contained either only male or only female faces. The faces were presented in 6 combinations, each of which contained an emotional component, although the valence of the face was incidental to the task from the perspective of the participant (they were only instructed to attend left or right):Attend Happy, Ignore Fear (illustrated in Figure 1); Attend Happy, Ignore Neutral; Attend Neutral, Ignore Fear; Attend Neutral, Ignore Happy; Attend Fear, Ignore Neutral; Attend Fear, Ignore Happy. The position of the type of emotion was counterbalanced across the experiment. The presentation of the two faces—one of which was to be remembered and one of which was to be ignored according to the arrow's direction--was followed a delay period, during which time participant should have retained the cued-face in memory. Lastly, a single test probe face appeared in the center of the screen. The probe required a positive response, made by pressing the “1” key on the keyboard, if it matched the face that the arrow had pointed to (Valid). It required a negative response, made by pressing the “0” key on the keyboard, if it was either the face that the arrow had not pointed to (Lure), or if it was a new face (Control). Control probes, which were always new neutral faces, were included in the design as a

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baseline for performance, as they were expected to show low false alarm rates. Participants completed 6 blocks of the task. Each block consisted of 6 Valid probe trials, 4 Lure probe trials and 4 Control probe trials. The experimental task was presented using E-Prime software (Psychology Software Tools, Inc., Pittsburgh, PA).

Results

The main data of interest were the discriminability index (*d′*), Hit Rates (correctly saying yes on Valid trials), and False Alarm Rates (incorrectly saying yes on Lure or Control trials) for HCs and PSZ. We began by investigating *d′*, which provides an overall index of performance on the task. As is illustrated in Table 2, the PSZ had significantly higher *d*'*s* than did HCs, indicating that they performed better on the task overall (t(45)=2.16, p=.04).

To determine whether PSZ did better on the task because they said yes on Valid trials more than did HCs, or because HCs false alarmed on Lure or Control trials more than did PSZ, we separately examined Hit Rates and False Alarm Rates, as independent factors. A Group (HC vs. PSZ) by Index (Hit Rates vs. False Alarm Rate) ANOVA revealed a significant interaction ($F(1,45)=3.96$, $p=.05$). There was no difference in Hit Rate between Groups. However, PSZ had a lower False Alarm Rates than did HCs. Post-hoc t-tests confirmed that Hit Rate did not differ by Group (t(45)=1.39, *ns*). Both PSZ and HC exhibited high Hit Rates. However, PSZ had a significantly lower False Alarm Rates than did HCs (t(45)=2.28, p=.03). The main effect of Hit Rate versus False Alarm Rate was significant, of course ($F(1,45)=686.11$, $p=.000$), and the Group main effect was not significant ($F(1,45)<1$).

We next performed an ANOVA of the relationship between Group, False Alarm Rates for Lure versus Control Probes Types, and the 6 Emotional Conditions, which is illustrated in Figure 2.

The ANOVA revealed a significant effect of Group ($F(1, 45)=4.91$, $p=.03$). People with SZ made fewer false alarms than did HCs across all Emotional Condition types. The main effect of Emotional Condition was also significant ($F(1, 45)=6.29$, $p<.001$). Pairwise Bonferonni contrasts revealed that more false alarms were made in the Attend Neutral, Ignore Fear condition than in the Attend Fear, Ignore Neutral condition (p=.02), and in the Attend Neutral, Ignore Happy condition than in the Attend Fear, Ignore Neutral condition (p=.01). Neither the main effect of Probe Type (Lure vs. Control), nor any of the interactions were significant.

Consistent with the design of the experiment, we were interested in investigating whether HCs demonstrated a pattern of results that would fit with previous research showing impaired attentional control when the distracting, to-be-ignored information was emotional as opposed to neutral (Perlstein, Elbert & Stenger, 2002). Accordingly, we collapsed across the valence of emotional stimuli (Happy and Fearful) and compared performance on the Lure trials when the target was emotional and the distractor was neutral to when the target was neutral and the distractor was emotional. Indeed, a paired *t*-test revealed that HCs said yes in error significantly more when they were to attend to a neutral face and ignore an emotional face than when they were to attend to an emotional face and ignore a neutral face

(t(24)=2.59, *p*=.02), suggesting that emotional information that should have been ignored was instead encoded by HCs. The same analysis conducted for PSZ was not significant (t(21)=1.9, *ns)*, suggesting that they did not encode the irrelevant, but emotional information.

We further investigated the relationship between performance (*d′*, Hit Rate and False Alarm Rate) and clinical symptoms (see Table 1) in PSZ. No correlations between performance and clinical symptoms were significant.

Finally, we investigated reaction times (RT) for PSZ and HCs. A generalized deficit in schizophrenia would predict slower RTs for PSZ than for HCs. As expected, there was a main effect of Group such that PSZ were slower than HCs overall (1332ms vs. 1136ms respectively, ($F(1, 45)=4.92$, $p=.03$)). The main effect of Probe Type was also significant ($F(2, 90)=5.43$, $p=.006$). Post-hoc Bonferonni tests revealed that Lure probes produced significantly longer RTs than Valid probes overall (1265ms vs. 1195ms respectively, $p=.014$). The interaction between Probe Type and Group was not significant ($F(1,45)<1$).

In summary, these results indicate that the locus of the benefit shown by the PSZ was that they said yes *in error* to the Lure items (the to-be-ignored distractors) and to unpresented Control items *less* frequently than did HCs.

Discussion

A number of studies have investigated attentional control, the effects of salient distractors on the maintenance of information in WM, and emotional recognition in PSZ as independent factors, yet few have investigated these processes in conjunction. In the current study, people with SZ and HCs completed a novel task in which they were instructed to attend to one face and ignore another based on the direction of an instruction-cue arrow. The emotional valence of the two presented faces was manipulated in such a way that sometimes the face that the participant should have ignored was neutral and the target was emotional, whereas other times the distractor was emotional (and the target item was either emotional or neutral).

In a previous study, we found that neither HCs nor PSZ had difficulty ignoring neutral material before it had entered WM. According to past literature, however, HCs, have difficulty ignoring emotional materials. In the current study, we predicted that PSZ would perform better than HCs due to the very affective processing deficits that are central to their symptomatology. Consistent with our hypothesis, PSZs outperformed HCs. They had Hit Rates equivalent to (and in fact numerically higher than) HCs, and their *d*'*s* were higher than HCs. Most noteworthy, they outperformed HCs by making fewer false alarms. Given that PSZ generally show deficits in cognitive tasks (Chapman & Chapman, 1973), and that impairments in WM are thought to be a hallmark cognitive deficit in the disease (Goldman-Rakic, 1994), these results are surprising.

Research in HCs suggests that affect labeling (the explicit verbal articulation of emotion) diminishes emotional reactivity (see Lieberman, Eisenberger, Crockett, Tom, Pfeifer & Way, 2007). In our task, emotion was attended to incidentally. An arrow instructed

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participants to attend to and remember the face on the left or the right side of the screen, which could be either an emotional or a neutral face. The emotional component of the task was therefore never made explicit to the participants. However, in every trial, emotional information was present: when a participant was to attend to a neutral face, the distractor face was an emotional face, and when the distractor face was neutral, the target face was emotional. Because of this, emotional information may have been particularly salient to HCs, regardless of Emotional Condition. PSZ, who show deficits in the processing of emotion (Kohler et al., 2010), may have derived a benefit to performance due to emotional processing deficits; just as they performed on par with HCs in our previous study in which neutral words were used, in the current study, the introduction of emotionally valenced stimuli did not lead to impairments in attentional control at encoding.

The amygdala is thought to play a key role in affective processing (see LeDoux, 2000). A study by Gur et al., (2002) found under-recruitment of the left amygdala in PSZ during a valence discrimination task in which participants had to distinguish positive from negative facial expressions. This under recruitment was hypothesized as an explanation for typical emotion processing deficits seen in PSZ. A more recent meta-analysis by Anticevic, Van Snellenberg, Cohen, Repovs, Dowd and Barch (2012) investigated amygdala activation in PSZ during tasks that used emotionally evocative stimuli, including faces and IAPS. Results of this study showed only small differences in amygdala activation when PSZ were compared directly to HCs, in contrast to the findings of Gur et al., (2002). However, amygdala under-recruitment was reported for tasks in which neutral information was contrasted with emotional information. It is possible that the superior performance of PSZ in our task may be tied to this finding. HCs, but not PSZ, made mistakes significantly more often when they were supposed to attend to a neutral face and ignore an emotional face as compared to compared to when they needed to attend to an emotional face and ignore a neutral face. One explanation for this pattern is that people with SZ may not orient towards emotional information in the same way as HCs because they are exhibiting dysfunctional amygdala activity due to the simultaneous presentation of both emotional and non-emotional stimuli. If PSZ are not drawn to or distracted by emotionally salient information in the task, they may be able to focus attention on the goal-relevant, to-be-remembered stimuli and ignore all other information, even emotional information. The lack of automatic orienting to such information might result in fewer false alarms to information that should not have been attended to in the first place, according to the task requirements.

Limitations

First, RT differences might have had an effect on our results. We found that PSZ reacted more slowly than did HCs overall, which suggests that their superior performance could be attributed to a speed-accuracy tradeoff. However, if this were the case, an interaction between Group and Probe Type would be expected, such that PSZ would be particularly slow in conditions in which their performance was especially good. However, the interaction between Probe Type and Group was not significant. Second, the data suggest that PSZ might be reacting to emotional stimuli as if they were neutral stimuli. A follow up study containing a Neutral-Neutral versus an Emotional-Neutral condition could help to determine whether or not this is the case. People with SZ would be expected to perform equivalently to HCs on

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the Neutral-Neutral condition (as they did in our previous study which contained only neutral words, see Smith et al., 2011). However, in the Emotional-Neutral condition we would expect results similar to the present results, such that PSZ would perform better than HCs. Finally, follow-up, using a larger sample size, an increased number of experimental trials, and brain imaging to investigate amygdala activity during the task, would help to determine the precise nature of patient's superior performance.

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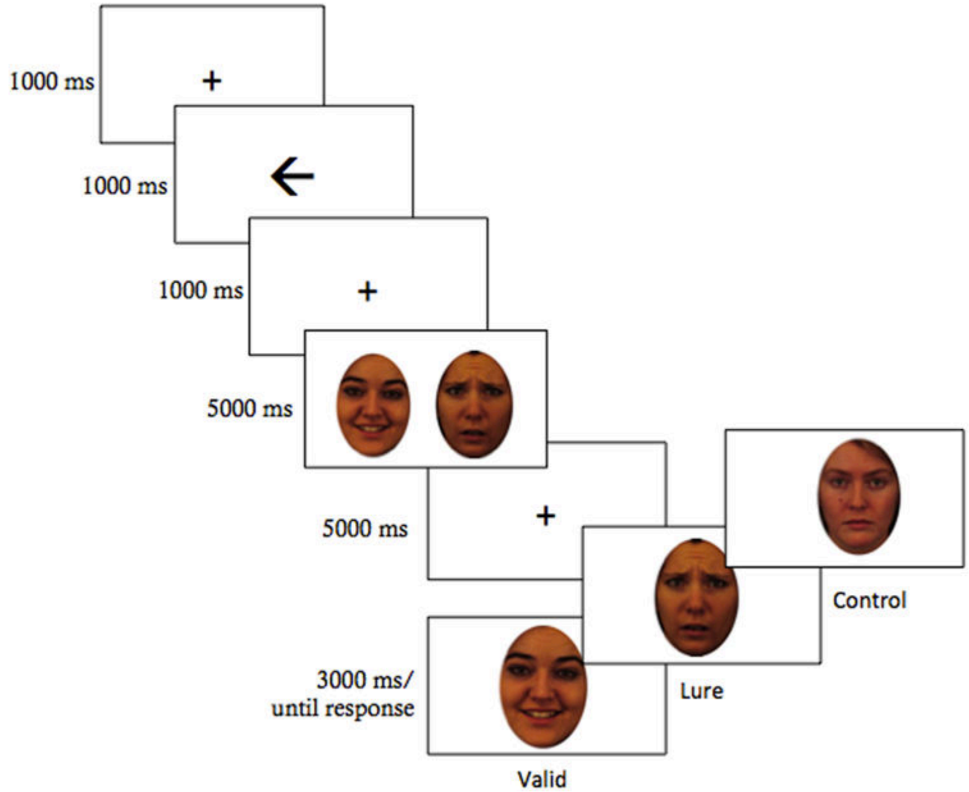

Figure 1.
Task schematic (illustrating an Attend Happy, Ignore Fear trial).

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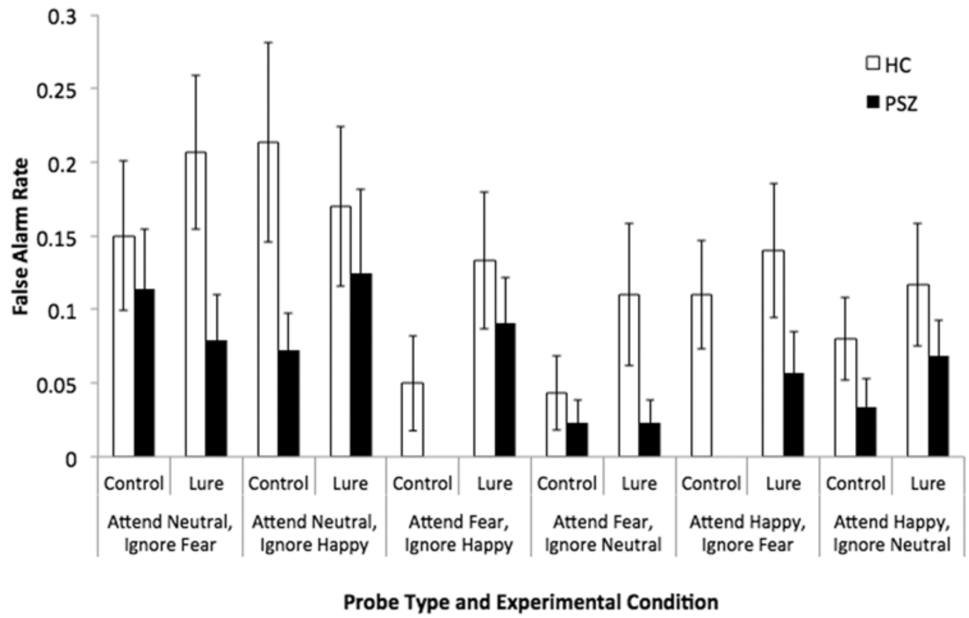

Figure 2.

False Alarm Rates on trials that required a negative response (Lure and Control trials) for People with Schizophrenia (PSZ) and Healthy Controls (HC) by Emotional Condition. Error bars represent standard error of the mean. Note that in the task, participants were instructed to attend to the face on the left or right side of the screen by virtue of an arrow-cue, not a word-cue.

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Table 1

Demographics and clinical ratings for People with Schizophrenia (PSZ) and Healthy Controls (HC).

Variable	People with Schizophrenia		Healthy Controls	
	Mean (SD)	*N*	*Mean (SD)*	*N*
Age (in years)	39.6 (8.2)	22	40.6 (8.5)	25
Sex (M/F)	10/12		14/11	
Handedness				
Right	15		22	
Left	5		2	
Ambidextrous	0		1	
Education (in years)	15.2 (1.9)	22	14.4 (1.4)	25
Mother's Education	13.7 (4.4)	21	13.6 (2.1)	24
Father's Education	14.9 (4.4)	20	13.9 (3.0)	23
Age of Onset	25.2 (8.4)	17		
CPZ Equivalent	305.2 (381.7)	16		
SANS				
Affective Flattening	5.4 (8.8)	20		
Alogia	1.9 (2.5)	20		
Avolition/Apathy	7.38 (4.7)	13		
Asociality/ Anhedonia	7 (6.7)	19		
Global	5.25 (4.0)	16		
Total	17.05 (14.5)	22		
SAPS				
Hallucinations	6.26 (8.6)	19		
Delusions	3.1 (5.5)	20		
Bizarre behavior	0.53 (1.9)	10		
Thought Disorder	2.3 (4.2)	20		
Global	2.84 (3.3)	19		
Total	10.77 (14.7)	22		
Hamilton Depression	2.85 (3.3)	20		

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Table 2

Performance on the task as measured by *d′*, Hit Rate and False Alarm rate for People with Schizophrenia (PSZ) and Healthy Controls (HC).

Variable (Mean (SD))			
	Hit Rate	**False Alarm Rate**	***d* Prime**
HC	0.87 (.16)	0.13 (.13)	2.73 (1.14)
PSZ	0.93 (.08)	0.06 (.06)	3.35 (.77)