Published in final edited form as:

Schizophr Res. 2012 March ; 135(1-3): 95–99. doi:10.1016/j.schres.2011.11.005.

Intact Motivated Attention in Schizophrenia: Evidence From Event-Related Potentials

William P. Horan,

VA Greater Los Angeles Healthcare System, University of California, Los Angeles

Dan Foti,

Stony Brook University

Greg Hajcak,

Stony Brook University

Jonathan K. Wynn, and

VA Greater Los Angeles Healthcare System, University of California, Los Angeles

Michael F. Green

University of California, Los Angeles, VA Greater Los Angeles Healthcare System

Abstract

Emotionally significant stimuli typically capture attention (called motivated attention) even when they are irrelevant to tasks where attention is directed. Previous studies indicate that several components of emotional processing are intact in schizophrenia when subjects are instructed to attend to emotionally-evocative stimuli. However, few studies have examined whether emotional stimuli capture attention to a normal degree in people with schizophrenia when attention is directed elsewhere. The current event-related potential study examined motivated attention to task-irrelevant emotional stimuli in 35 stabilized outpatients and 26 healthy controls with a modified visual P300 oddball detection task. Participants viewed images of rare target and commonly occurring standard letter stimuli, as well as intermixed emotional (unpleasant, pleasant, neutral) pictures. Subjects were instructed to count the number of rare targets; the emotional valence of the picture stimuli was, therefore, task-irrelevant. We separately evaluated the Early Posterior Negativity (EPN) and Late Positive Potential (LPP) to emotional pictures and the P300 to target stimuli. Patients and controls showed similar patterns of EPN and LPP amplitude to the emotional stimuli, such that the EPN and LPP were larger for both pleasant and unpleasant versus neutral pictures. Although patients performed worse than controls on the target counting task, both groups showed comparable P300 differentiation between target versus non-target stimuli. Emotional stimuli captured attentional resources in people with schizophrenia even when the emotional stimuli were task-irrelevant, suggesting intact motivated attention at the level of early electrophysiological responding.

© 2011 Elsevier B.V. All rights reserved.

Please address correspondence to: William P. Horan, Ph.D., University of California, Los Angeles & VA Greater Los Angeles Healthcare System, MIRECC 210A, Bldg. 210, 11301 Wilshire Blvd., Los Angeles, CA 90073, Phone: (310) 478-3711 x44041, Fax: (310) 268-4056, horan@ucla.edu.

¹We also examined potential ERP differences between patient subgroups based on a median split on the BPRS negative symptoms subscale (low scorers = 21; high scorers = 14). There were no significant differences for any of the ERP variables.

Contributors

Drs. Horan, Hajcak, and Green designed the study. All authors contributed to data analysis and interpretation. Dr. Horan wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

Conflict of Interest

None

Keywords

Schizophrenia; Event-Related Potentials (ERP); Late Positive Potential; P300; Emotion

1. Introduction

People with schizophrenia often show diminished emotional expression and pleasurable experiences based on clinical rating scales (Blanchard *et al.*, 2011). However, when directly exposed to evocative stimuli (e.g., pictures, foods), patients show normal emotion-modulated experiential, cardiovascular, electrodermal, and startle eyeblink responses (Kring and Moran, 2008). Motivationally relevant stimuli rarely present themselves in this way in daily life; they are often incidental to the primary tasks we are performing. In healthy subjects, incidental emotional stimuli naturally capture attention, an adaptive process called “motivated attention” (Bradley, 2009). Adaptive functioning, however, requires an optimal balance: incidental emotional stimuli need to capture attention but not deplete the resources required for ongoing goal-directed pursuits. The current study used an event-related potential (ERP) paradigm to evaluate processing of task irrelevant emotional stimuli in schizophrenia.

In healthy subjects, two ERPs, the early posterior negativity (EPN) and late positive potential (LPP), are larger for both pleasant and unpleasant compared with neutral pictures, reflecting increased attention to motivationally relevant stimuli (see Hajcak *et al.*, 2010). The EPN (200–300 ms) reflects early and relatively automatic selective attentional processing, whereas the LPP (400 – 1000 ms) reflects more sustained allocation of attentional resources. Consistent with the concept of motivated attention, the EPN and LPP are larger for emotional than neutral pictures even when the valence of pictures is irrelevant to the primary task to which attention is directed (Hajcak *et al.*, 2010).

Recently, we found patients showed generally normal early and late ERP’s to emotional versus neutral pictures during a task in which subjects attended to the pictures (Horan *et al.*, 2010). However, we are not aware of any prior studies that examined whether patients also show intact ERPs to task-irrelevant emotional images. To address this question, the current study used a modified visual P300 task modeled on Fichtenholtz *et al.* (2004) that involved rare target letter stimuli intermixed with irrelevant images of varying emotional content. A handful of behavioral and functional magnetic resonance imaging (fMRI) studies show mixed evidence of intact versus impaired automatic emotional processing in schizophrenia (e.g., Dichter *et al.*, 2010, Roux *et al.*, 2010, Schwartz *et al.*, 2010, Strauss *et al.*, in press); our prior ERP study led to the prediction that patients would show a larger EPN and LPP to task-irrelevant emotional versus neutral stimuli, similar to healthy controls.

2. Methods

2.1 Participants

Thirty-five outpatients with schizophrenia based on the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID; First *et al.*, 1996). Patients were medicated at clinically determined dosages. Psychiatric symptoms were rated using the expanded 24-item Brief Psychiatric Rating Scale (BPRS; Kopelowicz *et al.*, 2008). Twenty-five healthy controls from the local community were screened with the SCID and SCID-II (Cluster A). Procedures were approved by the local Institutional Review Board. Groups were demographically comparable, except for personal education (Table 1).

2.3 ERP paradigm

To elicit the P300, two letters ('X' and 'O') were chosen as visual stimuli. The 'O' was always the standard and presented with a probability of 85%, while the 'X' was always the target and presented with a probability of 15%. To elicit the EPN and LPP, 20 pleasant, 20 unpleasant, and 20 neutral pictures from the International Affective Picture System (IAPS; Lang *et al.*, 2005) were presented with equal probability. Participants were told they would view a series of letters and pictures on the screen, and that their task was to count silently the number of times the 'X' appeared. Thus, picture valence was irrelevant to the target detection task where attention was directed. After instruction and practice, participants performed 400 total trials, with breaks after each block of 50 trials. Each block consisted of a series of trials in which letters or pictures were presented in an alternating sequence from trial-to-trial. Each trial consisted of a letter or picture presented for 1 sec, and intertrial interval of 300 msec. Order of standards, targets, and pictures was randomly determined for each participant. After each block, participants were asked to input the number of targets presented.

2.4 EEG recording and processing

EEG activity was continuously recorded from 64 channels using a custom cap (Cortech Solutions, Wilmington, North Carolina, USA) and the ActiveTwo BioSemi system (BioSemi, Amsterdam, Netherlands; see Horan *et al.*, [in revision] for details). EEG data were re-referenced offline to the average of all electrodes and band-pass filtered with cutoffs of 0.1 and 30 Hz. EEG was segmented beginning 200 ms before each stimulus and continuing for 1000 ms post stimulus onset. Each EEG segment was corrected for blinks and physiological artifacts using standard procedures. ERPs were constructed by separately averaging segments of the five stimulus types (X and O images; pleasant, unpleasant, neutral pictures). Average activity in the 200-ms window prior to picture onset was the baseline. For letters, P300 was mean activity from 350–450 ms at Pz. For pictures, EPN was quantified as the mean activity from 200–300 ms at temporo-occipital sites (Oz,O1,O2,POz,PO3,PO4) and the LPP was quantified as the mean activity from 400–1000 ms at fronto-central sites (CPz,C1,Cz,C2,FCz; where effects were largest in this sample).

3. Results

3.1. ERP's to pictures

Grand average ERPs are presented in Figures 2 and 3, and mean ERP amplitudes are presented in Table 2. For the EPN, a 3 (Valence) X 2 (Group) repeated-measures ANOVA revealed a significant Valence effect. Compared to neutral pictures, LPP was significantly more positive for both unpleasant, $t(60) = 5.23$, $p < .001$, and pleasant pictures, $t(60) = 4.38$, $p < .001$, which did not significantly differ from each other, $t(60) = 1.39$, $p > .05$. The Group and Interaction effects were not significant, indicating a similar pattern of enhanced EPN for emotional pictures across groups.

For the LPP, there was a significant Valence effect indicating that, compared to neutral pictures, LPP was significantly more positive for both unpleasant, $t(60) = 5.51$, $p < .001$, and pleasant pictures, $t(60) = 3.46$, $p < .001$, which did not significantly differ from each other, $t(60) = .99$, $p > .05$. There was a trend-level Group effect ($p = .08$) and the Interaction effect was non-significant, indicating that the pattern of enhanced LPP for emotional pictures was also similar across groups.

3.2 Target detection task

As shown in Table 3, patients were significantly less accurate at counting the target stimuli than controls. For P300, grand average ERPs are shown in Figure 1. A 2 (Trial Type) X 2

(Group) repeated-measures ANOVA revealed a significant Trial Type effect, indicating that P300 for target trials was significantly more positive than for standard trials. The Group and Interaction effects were not significant, indicating a similar P300 pattern across groups.

3.3 Exploratory correlations with symptoms

Within the schizophrenia group, the ERP variables showed no significant or trend-level correlations with BPRS positive, negative, and total symptom scores¹.

4. Discussion

This study found normal early and late emotion-modulated ERPs in schizophrenia. Hence, the results from our earlier study (Horan et al., 2010) extend to processing task-irrelevant emotional stimuli. Automatic “grabbing” of attention by, and sustained processing of, emotional stimuli may reflect yet another area of relatively preserved emotion processing in schizophrenia. Our paradigm also allowed us to evaluate performance and ERPs in the target detection task where attention was directed. The patients showed impaired counting of the targets, consistent with a working memory deficit (Lee and Park, 2005). However, the groups showed comparable P300 differentiation between target and standard stimuli, as reported in some prior studies of visual target detection tasks (e.g., Bestelmeyer *et al.*, 2009, Luck *et al.*, 2009). Results suggest patients could allocate resources to the target and inhibit the impact of emotional stimuli, and they contribute to research on the interface between emotion and cognition in schizophrenia (Kring and Caponigro, 2010).

One study used a comparable target detection paradigm to ours, but with fMRI instead of EEG (Dichter et al., 2010). In contrast to our findings, that study found schizophrenia outpatients showed (a) diminished activation in frontolimbic regions to task-irrelevant unpleasant stimuli and (b) dorsal frontal hypoactivation and reduced frontolimbic deactivation during target detection trials, a pattern thought to reflect impaired inhibitory processes linked to shifting between attentional and emotional domains. This discrepancy may reflect differences in the neural network associated with the ERPs examined (Sabatinelli *et al.*, 2007), various task parameters (e.g., our inclusion of both pleasant and unpleasant stimuli), or temporal resolution of ERP versus the more sluggish BOLD response. This discrepancy highlights the importance of examining the interface between emotion and cognition across multiple methods and time frames.

The current study suggests that motivated attention is intact in schizophrenia and may be a relative strength in terms of adaptive functioning; preferential processing of motivationally significant stimuli can rapidly draw attention to potential threats or rewards so that they can then be appropriately managed. If replicated, this information can help facilitate understanding and treating the functional impairments associated with schizophrenia. If basic neurophysiological processing of emotional stimuli is largely intact, efforts to identify and treat higher-level integrative or regulatory processing impairments that impact functioning will likely be more productive (Barch and Dowd, 2010, Kring and Caponigro, 2010).

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all final disclaimers that apply to the journal pertain.

Acknowledgments

The authors would like to thank and acknowledge the following people who contributed to the data collection for the study: Mark McGee, Crystal Gibson, Cory Tripp, Katie Weiner, and Poorang Nori.

Role of Funding Sources

This work was supported by a NARSAD Young Investigator Award (to WPH) and the National Institute of Mental Health (MH082782 to WPH; MH065707, MH43292 to MFG). Funding sources had no role in study design or in the collection, analysis and interpretation of data; or in the writing of this report.

References

- Barch DM, Dowd EC. Goal Representations and Motivational Drive in Schizophrenia: The Role of Prefrontal-Striatal Interactions. *Schizophrenia Bulletin*. 2010; 36:919–934. [PubMed: 20566491]
- Bestelmeyer PE, Phillips LH, Crombie C, Benson P, St Clair D. The P300 as a possible endophenotype for schizophrenia and bipolar disorder: Evidence from twin and patient studies. *Psychiatry Res*. 2009; 169:212–219. [PubMed: 19748132]
- Blanchard JJ, Kring AM, Horan WP, Gur R. Toward the Next Generation of Negative Symptom Assessments: The Collaboration to Advance Negative Symptom Assessment in Schizophrenia. *Schizophrenia Bulletin*. 2011; 37
- Bradley MM. Natural selective attention: orienting and emotion. *Psychophysiology*. 2009; 46:1–11. [PubMed: 18778317]
- Dichter GS, Bellion C, Casp M, Belger A. Impaired modulation of attention and emotion in schizophrenia. *Schizophr Bull*. 2010; 36:595–606. [PubMed: 18843096]
- Fichtenholtz HM, Dean HL, Dillon DG, Yamasaki H, McCarthy G, LaBar KS. Emotion-attention network interactions during a visual oddball task. *Brain Res Cogn Brain Res*. 2004; 20:67–80. [PubMed: 15130591]
- First, MB.; Gibbon, M.; Spitzer, RL.; Williams, JBW. Structured Clinical Interview for DSM-IV Axis I Disorders Patient Edition. New York: Biometrics Research; 1996.
- Hajcak G, MacNamara A, Olvet DM. Event-related potentials, emotion, and emotion regulation: an integrative review. *Developmental Neuropsychology*. 2010; 35:129–155. [PubMed: 20390599]
- Horan WP, Foti D, Hajak G, Wynn JK, Green MF. Impaired neural response to internal but not external feedback in schizophrenia. (in revision).
- Horan WP, Wynn JK, Kring AM, Simons RF, Green MF. Electrophysiological correlates of emotional responding in schizophrenia. *Journal of Abnormal Psychology*. 2010; 119:18–30. [PubMed: 20141239]
- Kopelowicz A, Ventura J, Liberman RP, Mintz J. Consistency of Brief Psychiatric Rating Scale factor structure across a broad spectrum of schizophrenia patients. *Psychopathology*. 2008; 41:77–84. [PubMed: 18033976]
- Kring AM, Moran EK. Emotional response deficits in schizophrenia: Insights from affective science. *Schizophrenia Bulletin*. 2008; 34:819–834. [PubMed: 18579556]
- Kring JM, Caponigro MM. Emotion in schizophrenia: Where feeling meets thinking. *Current Directions in Psychological Science*. 2010; 19:255–259. [PubMed: 22557707]
- Lang, PJ.; Bradley, MM.; Cuthbert, BN. International affective picture system (IAPS): Affective ratings of pictures and instruction manual Technical Report A-6. Gainesville, FL: University of Florida; 2005.
- Lee J, Park S. Working memory impairments in schizophrenia: A meta-analysis. *Journal of Abnormal Psychology*. 2005; 114:599–611. [PubMed: 16351383]
- Luck SJ, Kappenman ES, Fuller RL, Robinson B, Summerfelt A, Gold JM. Impaired response selection in schizophrenia: evidence from the P3 wave and the lateralized readiness potential. *Psychophysiology*. 2009; 46:776–786. [PubMed: 19386044]
- Roux P, Crhistophe A, Passerieux C. The emotional paradox: Dissociation between explicit and implicit processing of emotional prosody in schizophrenia. *Neuropsychologia*. 2010; 48:3642–3649. [PubMed: 20801135]

- Sabatinelli D, Lang PJ, Keil A, Bradley MM. Emotional perception: correlation of functional MRI and event-related potentials. *Cerebral Cortex*. 2007; 17:1085–1091. [PubMed: 16769742]
- Schwartz BL, Vaidya CJ, Howard JH, Deutsch SI. Attention to gaze and emotion in schizophrenia. *Neuropsychology*. 2010; 24:711–720. [PubMed: 20873932]
- Strauss GP, Llerena K, Gold JM. Attentional Disengagement from Emotional Stimuli in Schizophrenia. *Schizophrenia Research*. (in press).

Figure 1. The EPN grand average at a pooled electrodes Oz, O1, O2, POz, PO3, PO4 for unpleasant, pleasant, and neutral pictures for control (left) and schizophrenia (right) groups. Stimulus onset occurred at 0 ms and negative is plotted up.

Figure 2. The LPP grand average at pooled electrodes CPz, C1, Cz, C2, FCz for unpleasant, pleasant, and neutral pictures for control (left) and schizophrenia (right) groups. Stimulus onset occurred at 0 ms and negative is plotted up.

Figure 3. The P300 grand average at Pz for standard and target trials for control (left) and schizophrenia (right) groups. Stimulus onset occurred at 0 ms and negative is plotted up.

Table 1

Demographic and Clinical Data

	Schizophrenia (N = 35)	Controls (N = 26)	Statistic
Sex (% male)	74.3	73.1	$X^2 (1,61) = .92$
Age (SD)	48.3 (7.6)	44.9 (8.5)	$t(59) = 1.66$
Ethnicity			
White	41.2	46.2	$X^2 (4,61) = 3.73$
African American	38.2	42.3	
Asian	8.8	3.8	
Hispanic	8.8	0.0	
Other	2.9	7.7	
Marital status			
Never married	62.9	65.4	$X^2 (2,61) = 3.95$
Currently married	5.7	19.2	
Ever married	31.4	15.4	
Education (SD)	13.2(1.6)	14.5(1.7)	$t(59) = 3.10^*$
Parental education (SD)	13.9(3.4)	14.9(2.1)	$t(59) = .18$
Age of onset (SD)	22.0 (5.8)		
Duration of illness (SD)	26.0 (8.8)		
BPRS			
Positive symptoms (SD)	2.1 (0.8)		
Negative symptoms (SD)	1.7(0.9)		
Total (SD)	41.4(10.5)		

Notes: BPRS = Brief Psychiatric Rating Scale. The patients had lower personal education levels than controls but the groups did not differ in parental education, which was the variable intended to control for family socio-economic status, as opposed to personal education, which can be influenced by the illness itself.

** $p < .005$

ERP Data for Pictures

Table 2

	Schizophrenia (N = 35)	Controls (N = 26)	F values		
			Valence (df = 2,59)	Group (df = 1,59)	Valence X Group (df = 2,59)
Early Posterior Negativity			17.63 ***	.01	1.40
Neutral	3.71 (3.31)	3.91 (2.64)			
Pleasant	3.19(3.32)	3.15(2.96)			
Unpleasant	3.09 (3.08)	2.77 (2.74)			
Late Positive Potential			19.07 ***	3.16 [†]	.32
Neutral	.13(1.17)	.61 (1.36)			
Pleasant	.97(1.70)	1.32(1.14)			
Unpleasant	1.07(1.46)	1.60(1.67)			

Note: Mean scores reflect mean amplitudes. Standard deviations are presented in parentheses.

[†]
p < .10;

p < .001

Target Detection Task

Table 3

	Schizophrenia (N = 35)	Controls (N = 26)	t-value (df = 59)		
Target counting task	61.76% (28.36%)	78.00% (25.33%)	2.27 *		
			F values		
			Trial Type (df = 1,59)	Group (df = 1,59)	Type X Group (df = 1,59)
P300			18.22 ***	.05	.05
Target	-.38 (1.40)	-.41 (1.41)			
Standard	.97 (2.34)	.82 (2.57)			

Note: Accuracy on the target counting task was based the percentage of trial blocks in which the number of reported targets correctly matched the actual number of presented targets. P300 means reflect mean amplitudes. Standard deviations are presented in parentheses.

*
p < .05;

p < .001