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Early visual information processing deficit in depression with and without Borderline Personality Disorder

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Abstract

Backward masking is a measure of early visual information processing usually abnormal in psychotic disorders. Previous studies of subjects with Borderline Personality Disorder have been inconsistent regarding their impairment or lack of impairment on backward masking. We examined visual backward masking performance in samples of unmedicated depressed patients with ($n=12$) and without ($n=16$) Borderline Personality Disorder, and healthy volunteers ($n=18$). Accuracy was poorer in depressed BPD patients, relative to both non-BPD depressed and healthy comparison subjects. As in previous studies, no differences in accuracy were found between non-BPD depressed patients and healthy comparison subjects. Differences in BPD subjects' accuracy were most evident at the fastest ISI and were not attributable to intercurrent psychotic symptoms. Beyond these group differences, accuracy at faster ISI's correlated with self-ratings of impulsiveness in all patients, and may be a general correlate of this trait. Poor early information processing appears to be a feature of Borderline Personality Disorder, and may play a role in the impulsive behavior that is characteristic of the disorder.

Keywords

Backward masking; Borderline Personality Disorder; Depression; Information processing; Impulsiveness; Impulsiveness assessment

1. Introduction

Individuals with Borderline Personality Disorder (BPD) may experience transient psychotic states (Stern, 1938; Frosch, 1964; Kernberg, 1975; Gunderson, 1984; Brodsky et al., 1997), and possibly share neuropsychological characteristics with psychotic disorders (Lenzenweger et al., 2004). Neuropsychological studies of BPD, however, suggest that the most common deficits in this disorder are those associated with affective illness, namely deficits in attention and memory (Burgess, 1991; Kurtz and Morey, 1999; Posner et al., 2002). There have been few studies examining the earliest stages of information processing in BPD, via tasks such as backward masking. Deficits in early information processing may underlie some of the distortions of reality and seemingly irrational behavior in both psychosis and BPD, and warrant further scrutiny.

Backward masking is a measure of early information processing and visual perception that involves very brief presentation of a target stimulus followed closely in time by a second “masking” stimulus that interferes with processing of the target (Turvey, 1973; Breitmeyer and Gantz, 1976; Rund et al., 1993; Green et al., 1994b; McClure, 1999). Degree of disruption in the processing of the target is a function of the temporal delay between the target and the mask (interstimulus interval or ISI). Backward masking performance is typically most impaired when the target and mask are presented contiguously and improves as the onset of the mask is delayed further in time (Braff, 1981; Rund et al., 1993; McClure, 1999; Butler et al., 2002; MacQueen et al., 2001).

Research on backward masking performance has historically focused on psychotic disorders, where it is a predictor of a vulnerability to schizophrenia (Balogh and Merritt, 1987; Green and Nuechterlein, 1999). However, it is unclear if impaired backward masking is specific to schizophrenia spectrum disorders (Rund et al., 2004). Studies comparing backward masking performance of subjects with bipolar disorder to that of non-patients have been inconsistent (Saccuzzo and Braff, 1981; Green and Walker, 1986; Rund, 1993; Green et al., 1994a; Fleming and Green, 1995; MacQueen et al., 2001). Studies comparing backward masking performance of subjects with major depression without psychotic features to that of non-patients, on the other hand, consistently find no differences (Saccuzzo and Braff, 1981, 1986; Elkins et al., 1992; Suslow and Arolt, 1997, 1998; Rund et al., 2004).

Two studies have examined backward masking in subjects with BPD. The first found no differences between a small group of BPD subjects ($n=8$) and both non-psychotically depressed patients and non-patients (Schubert et al., 1985). Two comparison samples of schizoaffective and manic bipolar subjects performed more poorly than these other groups. Most of the BPD subjects in that study (6 of 8 subjects; 75% of sample) were receiving psychotropic medication at the time of assessment, and met criteria for minor depression. A more recent study of a larger group ($n=22$) of predominately unmedicated BPD subjects (19/22; 86.4% of sample unmedicated) found they differed from healthy controls in requiring a longer ISI to identify target stimuli at better than chance levels (Stevens et al., 2004). BPD subjects’ backward masking difficulties were linked to a more general set of cognitive impairments that included deficits in working memory. However, this study did not include a psychiatric comparison group, and it was unclear if these deficits were unique to BPD.

On the basis of these prior reports, we hypothesized that unmedicated, depressed BPD subjects would exhibit deficits on backward masking. We further hypothesized that these deficits would be related to behavioral characteristics of BPD, such as impulsiveness, hostility, and aggression. Performance on a computerized backward masking task using a single number target and spatially overlapping mask was compared among samples of unmedicated depressed subjects with and without BPD, and healthy volunteers. Correlations between backward masking performance and impulsiveness, hostility, and aggression measures were examined as well.

2. Methods

2.1. Subjects

Subjects were 28 depressed patients meeting DSM-IV criteria for either unipolar major depressive disorder ($n=21$) or bipolar disorder, depressed ($n=7$). This patient sample included 12 subjects with comorbid Borderline Personality Disorder and 16 without. The 16 depressed non-BPD subjects included 11 with no Axis II disorders, 2 with Avoidant Personality Disorder, 1 with Obsessive–Compulsive Personality Disorder and 2 with Personality Disorder, Not Otherwise Specified. Patient groups were compared to 18 healthy

volunteers with no current or past Axis I or Axis II disorders. Subjects in all three of the study groups were free of medical and neurological disorders likely to affect testing such as head injuries, stroke, or chronic illnesses (via physical exam and history) and of any current substance use (urine assay). All subjects were recruited via advertisement or referral from local clinicians for participation in studies conducted within the Conte Center for the Study of Suicidal Behavior at the New York State Psychiatric Institute.

Patient subjects were psychotropic medication-free for at least 2 weeks prior to testing (4 weeks for antipsychotics, 5 weeks for fluoxetine), as part of their participation in other biological procedures in our center. This study was approved by the local institutional review board, and all subjects signed informed consent prior to participation.

2.2. Clinical assessment

Structured Clinical Interviews for the DSM-IV (SCID) were used to determine Axis I and Axis II diagnoses for patients (Spitzer et al., 1990; First et al., 1996). Axis II assessments were completed after treatment to insure that Axis II diagnosis was not confounded by acute symptomatology. Healthy controls were assessed using the nonpatient version of the SCID (SCID-NP). Depression severity was assessed with the 24 item Hamilton Depression Scale (Hamilton, 1960) and the Beck Depression Inventory (Beck et al., 1961). Functional impairment was evaluated via the Global Assessment of Functioning (GAF; Endicott et al., 1976). Psychotic symptoms were assessed via the Brief Psychiatric Rating Scale (BPRS; Overall and Gorham, 1962); the total score as well as subscores for positive and negative symptoms (Lachar et al., 2001) were computed. Subjects also completed the Barratt Impulsiveness Scale (BIS: Barratt, 1994), the Buss-Durkee Hostility Inventory (Buss and Durkee, 1957) and the Brown-Goodwin Lifetime History of Aggression Scale (Brown et al., 1979). Past history of suicidal behavior was evaluated using a standard interview developed and validated in our center (Oquendo et al., 2003).

2.3. Backward masking procedures

Following clinical assessments, subjects completed the computerized backward masking task as part of a comprehensive neuropsychological assessment. The task was programmed in the PsyScope programming language (Cohen et al., 1993), and presented on a Macintosh computer. Stimuli were 7 mm high (subtending approximately 2° of visual angle) and included the numbers 6, 8, and 9. Target stimulus was the number 6. Subjects were asked to answer the question “Was it a 6?” by responding yes (press #1 on a numeric keypad) or no (press #3 on numeric keypad). Stimuli appeared on the computer screen for a fixed duration of 5 ms, followed by a mask consisting of four Xs (XXXX) presented for 500 ms. The mask was randomly delayed at six fixed intervals: 5 ms, 10 ms, 20 ms, 50 ms, 75 ms and 100 ms after termination of the stimulus, and presented overlapping the location of the target. Ten trials were presented at each ISI (four presentations of 6, three each of 8 and 9). Subjects were instructed to respond as quickly as possible. Accuracy rates at each ISI were computed, and reaction times recorded. Formal vision testing was not done, but all subjects were able to detect stimuli during an initial practice run. Because the mask overlapped the location of the target, a progressive improvement in performance with increasing ISI was expected. Metacontrast (presentation of the target near, but not overlapping the location of the target), which produces a U-shaped performance curve (Rassovsky et al., 2004), was not used in this study.

Backward masking effects depend on subjects being able to detect stimuli even if no mask is present. If a fixed stimulus duration is used that is below detection threshold for a given subject, all responses will be at chance levels. Because we used a fixed stimulus presentation rate (5 ms), we examined all individual subject data to determine if they were able to

perceive targets. If a subject responded at chance levels (<60% accuracy) at the longest ISI's (where performance typically rises to >90% accuracy; see Fig. 1.), and showed no change in performance across the various ISI's, they were unable to detect stimuli at the presentation rate. One subject in each group was eliminated for this reason prior to statistical analyses.

2.4. Statistical analyses

Demographic and clinical characteristics of the subject groups were compared using Analysis of Variance (ANOVA) and chi-squared analyses. The primary statistical analyses of backward masking performance involved Repeated Measures ANOVA with subject group as the between-subjects factor and ISI as the within-subjects factor, for both accuracy and reaction times. Age and sex were covaried in these analyses, given that these demographic factors have well-documented effects on backward masking performance (Cadenhead et al., 1997; Green et al., 2003), and given that groups differed in gender distribution and tended to differ in age (Table 1). Significance of the subject group by ISI interaction in the repeated measures ANOVA led to univariate contrasts at individual ISI's. Spearman correlations were then computed between backward masking results (adjusted for age and sex) and impulsiveness, hostility, and aggression measures. Alpha level was 0.05.

3. Results

3.1. Characteristics of study groups

Subject groups were comparable in age, education, and WAIS-R Vocabulary score (Table 1). The two patient groups differed significantly from non-patients on all clinical measures, as expected. The depressed non-BPD and depressed BPD groups were very similar, and only differed in the percentage of females in the group (BPD higher than both other groups). There were no differences in the percentages of past suicide attempters in each patient group. There was a trend toward a higher percentage of bipolar depressed subjects in the non-BPD group, but supplemental comparisons of bipolar and unipolar subjects did not reveal any differences between these diagnostic subgroups on backward masking measures, and exclusion of bipolar subjects did not affect any of the analyses described below. There were no differences in BPRS psychoticism ratings between the patient groups, either for total score, positive symptoms or negative symptoms.

The depressed non-BPD sample included 11 subjects with no Axis II disorders and 5 with other non-BPD personality disorders. Statistical analyses reported below were identical if this group was restricted to those with no Axis II disorder. Subjects with other non-BPD personality disorder were included in the depressed non-BPD group because they did not differ on backward masking from subjects without Axis II disorders.

3.2. Backward masking performance

The backward masking task produced the expected, systematic improvement in performance as ISI increased in all groups ($F[5,205]=2.34$, $P=0.04$), and there was a significant group by ISI interaction ($F[10,205]=1.88$, $P=0.05$). Overall group effect was not significant ($F[2,41]=1.43$, $P=0.25$), indicating that group differences were restricted to specific ISI's. BPD subjects' mean accuracy was poorer at faster ISI's (Fig. 1). Univariate analyses revealed significant group differences at only the 5 ms ISI ($F[2,41]=3.69$, $P=0.03$), with BPD subjects performing more poorly than both non-BPD depressed subjects and healthy non-patients ($P<0.05$ by Student Newman-Keuls post-hoc tests). No differences in accuracy were found between non-BPD depressed and healthy non-patients at any ISI, consistent with prior studies. The group by ISI interaction remained significant if the patient sample was restricted to unipolar subjects only ($F[10,170]=1.91$, $P=0.05$).

Reaction times did not differ significantly either across ISI's ($F[5,205]=0.48$, $P=0.79$), across groups ($F[2,41]=.54$, $P=0.59$), or across groups at any specific ISI ($F[10,205]=.70$, $P=0.72$).

Among all depressed patients, poorer accuracy at the faster ISI's was associated with higher scores on the Barratt Impulsiveness Scale (at 5-ms delay, $\rho=-0.56$, $P=0.005$; 10-ms delay, $\rho=-0.56$, $P=0.005$; 20 ms delay, $\rho=-0.45$, $P=0.03$; 50-ms delay, $\rho=-0.48$, $P=0.02$), but no other clinical variables, including Buss Durkee Hostility (at 5-ms delay, $\rho=-0.37$, $P=0.06$) and Brown–Goodwin Aggression History (at 5-ms delay, $\rho=-0.31$, $P=0.11$).

4. Discussion

This is the second study to find a relationship between BPD and poor backward masking performance. Our results are consistent with the previous positive study of primarily unmedicated subjects (Stevens et al., 2004); while the only negative study (Schubert et al., 1985) used a small sample of predominately medicated subjects (including 50% receiving antidepressants, with half of those receiving adjunctive antipsychotics, and 25% receiving sedatives). It is unclear if medication status plays a role in suppressing this deficit – it does not in schizophrenia – but degree of BPD symptom control may. Presence of depression, on the other hand, does not appear to play a role. While BPD subjects in our study all met criteria for major depression, subjects with BPD in the study by Stevens et al. were dysphoric but did not meet criteria for major depression.

Poor performance on the backward masking task is typically associated with risk for psychosis (Balogh and Merritt, 1987; Green and Nuechterlein, 1999). Transient psychotic states are often present in Borderline Personality Disorder and may be similar to the psychotic features present in the schizophrenia spectrum disorders (Stern, 1938; Frosch, 1964; Kernberg, 1975; Gunderson, 1984; Brodsky et al., 1997). On the other hand, one study of schizophrenic subjects linked backward masking performance to both affective flattening and anxiety (Suslow et al., 1998) and poor backward masking in subjects with BPD may be linked to their affective disturbances. It is noteworthy that differences between depressed BPD subjects and non-BPD depressed subjects in this study could not be attributed to differences in level of psychosis between the groups. The groups were equivalent in BPRS ratings, and BPRS scores did not correlate with backward masking performance measures.

In addition to the specific association between BPD and poor backward masking, poorer accuracy at faster ISI's was associated with impulsiveness. This association was not simply an effect of BPD subjects' higher mean score on this measure; the association between BIS score and backward masking accuracy was as high in the non-BPD group ($\rho=-.59$, $P=0.02$ at 5 ms ISI, for example) as in the patient group as a whole. The previously published study that found backward masking deficits in BPD subjects did not find an association between accuracy and impulsiveness, based on a rating derived from the Diagnostic Interview for Borderlines (DIB). However, this rating only has a range from 0–3, and the median score in the BPD group in that study was 3, at the ceiling of the scale. This attenuation of range would have made finding such an association very unlikely. In our study, impulsiveness was assessed with the Barratt Impulsiveness Scale, which has a much larger range (0–120 for this version of the scale). Nonetheless, the association between backward masking performance and Barratt Impulsiveness was somewhat attenuated in the BPD group ($\rho=-0.42$, $P=0.17$ at 5-ms ISI) due to their high scores, although the overall strength and slope of the association were similar to that in the non-BPD group.

There may ultimately be a more general association between sensory processing deficit and impulsiveness. Behavioral measures of this trait, unfortunately, have not typically examined the earliest stages of information processing. The most successful of these behavioral paradigms focus on disinhibition or complex response organization. Ratings of impulsiveness typically correlate with increased numbers of commission errors or a paradoxical slowing of response times as tasks become more complex, presumably due to failures of higher level response organization (Dougherty et al., 2003; Keilp et al., 2005). Our findings suggest that failures at the earliest stages of perceptual processing may also play a role in impulsive behavior, or at least that very rapid presentation of stimuli may induce impulsive responding in vulnerable subjects. In supplemental analyses, we observed that BIS score was more strongly associated with commission errors in the backward masking task (e.g. identifying an “8” or “9” as a target stimulus; $\rho=.52$, $P=0.01$) than omission errors (failure to identify “6” as a target, $\rho=.12$, $P=0.59$). As we had noted in an earlier paper (Keilp et al., op cit.), tasks that compel subjects to make decisions under time pressure tend to elicit impulsive responding.

As in previous studies (Saccuzzo and Braff, 1981, 1986; Elkins et al., 1992; Suslow and Arolt, 1997, 1998; Rund et al., 2004), we also found no differences in backward masking performance between depressed patients and non-patients. Backward masking, then, may provide insights into information processing deficits in BPD that are independent of comorbidity with depression.

Sample sizes in this study were small, and the backward masking task itself was relatively brief. Our normative studies suggest that the task is reliable (test-retest $r\sim.65$ for overall accuracy over four repeats in a month; Keilp, unpublished data), but a longer task that samples more ISI's might characterize BPD performance better. We did not incorporate a procedure to determine individual stimulus detection thresholds, but did exclude subjects who showed evidence of not being able to detect stimuli at even the longest ISI's. All subjects included in the analyses showed improvement in performance as ISI's increased, as is typical on this task.

Results of this study suggest that backward masking is a useful method for examining BPD psychopathology, especially for differentiating it from affective disorders. One unresolved issue is whether medications stabilize backward masking performance in BPD, and whether medication effects account for the one negative finding in the published literature. More broadly, backward masking may also be an effective method for examining neuropsychological mechanisms underlying the trait of impulsiveness, particularly in the context of major depression.

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Fig. 1. Backward masking performance accuracy ($\pm$ SEM) in healthy volunteers, depressed patients without BPD, and depressed patients with BPD.

Table 1
Demographic and clinical characteristics of healthy volunteers, depressed subjects without BPD and depressed subjects with BPD

	Healthy volunteers		Depressed non-BPD		Depressed BPD		Analysis	
	N=18		N=16		N=12			
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Signif	Contrast ^a
Age	39.94	15.98	41.44	12.41	33.42	6.67		
Education	16.83	2.23	17.19	3.37	15.96	2.26		
WAIS-III Vocabulary (Scaled)	13.89	2.17	13.00	2.19	12.83	3.35		
# Major Depressive Episodes			4.50	5.88	6.33	5.58		
Length current episode (weeks)			104.2	186.99	69.17	19.97		
Hamilton depression scale	1.39	2.12	26.93	6.72	26.67	7.57	**	C<N,B
Beck depression inventory	1.06	2.15	26.73	8.03	26.82	9.02	**	C<N,B
GAF (w/suicide items)	90.83	5.07	44.13	10.83	44.83	14.23	**	C>N,B
GAF (w/o suicide items)	90.83	5.07	45.25	9.78	45.33	13.96	**	C>N,B
BPRS total score	20.06	1.70	33.00	4.21	34.25	6.20	**	C<N,B
BPRS positive symptoms	5.00	0.00	5.25	0.58	5.67	0.98	*	C<B
BPRS negative symptoms	3.17	0.51	4.44	1.79	5.08	3.40	*	C<B
BIS total score	31.94	11.04	50.47	17.89	58.63	17.25	**	C<N,B
Buss Durkee total score	17.18	7.96	31.07	10.47	32.0	8.33	**	C<N,B
Brown-Goodwin total score	13.67	3.01	16.19	3.66	15.43	3.61	*	C<N,B
	N	%	N	%	N	%	Signif	Contrast ^a
Gender (% female)	7	38.9	7	43.8	10	83.8	*	C,N<B
Race (% Caucasian)	11	61.1	13	81.3	11	91.7		
Inpatient Status			13	81.3	7	58.3		
Psychopathology								
Bipolar depression			6	37.5	1	8.3		
Past substance abuse/dependence			5	31.3	4	33.3		
Suicide attempters			10	62.5	7	58.3		

* $P<0.05$.

^a_{**} $P < 0.01$

^a Student-Newman-Keuls post hoc comparisons; C=Healthy Comparison, N=Non-BPD, B=BPD.