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REWARD AND PUNISHMENT SENSITIVITY IN BORDERLINE AND AVOIDANT PERSONALITY DISORDERS

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The authors compared self-reported and behavioral responses to reward and punishment in individuals diagnosed with borderline personality disorder (BPD) or avoidant personality disorder (APD) relative to a healthy comparison (HC) group. As predicted, self-reported sensitivity to reward was significantly higher in the BPD group than in the APD and HC groups. Also as predicted, self-reported sensitivity to punishment was significantly elevated in both disordered groups but significantly higher in APD than in BPD. These hypothesized patterns were also evident in responses to behavioral tasks: Participants with BPD made more errors of commission and fewer errors of omission than HC participants on a passive avoidance learning task, and participants with APD showed greater reactivity to losses than other participants on a probabilistic reversal learning task. Results help characterize differences between these two disorders.

Keywords: reward, punishment, borderline, avoidant, passive avoidance learning, probabilistic reversal learning

Dysfunctional responses to reward and punishment are thought to underlie many forms of psychopathology (Vollum et al., 2007). For example, unusually high reward sensitivity may be implicated in disorders involving impulsive pursuit of gratification at a cost to other goals, whereas unusually high punishment sensitivity may be implicated in disorders involving reduced goal pursuit due to fearful avoidance of possible risk. Hence, while borderline personality disorder (BPD) and avoidant personality disorder (APD) are similarly

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characterized by long-standing psychosocial distress and rejection sensitivity (Berenson et al., 2018), there is reason to believe that distinct patterns of dysfunctional responses to reward and punishment may distinguish them; and no previous studies have specifically addressed this question. In this study, we examined responses to reward and punishment in individuals diagnosed with these disorders relative to a healthy comparison group, using self-report questionnaires and behavioral tasks.

RESPONSE SENSITIVITY THEORY AND PSYCHOPATHOLOGY

Individual differences in responses to reward and punishment are proposed to correspond to the activity of two distinct brain systems, the Behavioral Activation (or Approach) System (BAS), and the Behavioral Inhibition System (BIS; Gray, 1987; Gray & McNaughton, 2000). The BAS, responsive to reward and relief from punishment, is involved in impulsivity (Berkman, Lieberman, & Gable, 2009; Braddock et al., 2011; Nelson-Gray, Mitchell, Kimbrel, & Hurst, 2007), externalizing behaviors (Ross, Keiser, Strong, & Webb, 2013), and expressed anger (Smits & Kuppens, 2005). The BAS is also involved in extraversion, approach behavior, and feelings of elation, hope, and desire (Johnson, Turner, & Iwata, 2003; Kasch, Rottenberg, Arnow, & Gotlib, 2002). The BIS, by contrast, is responsive to punishment or perceived punishment, nonreward, and the termination of reward, and is involved in avoidance of stimuli that are feared, novel, or high in intensity. Self-report measures of BIS sensitivity have been positively correlated with internalizing behaviors (Ross et al., 2013), trait anxiety (Nelson-Gray et al., 2007), avoidance, inhibition, arousal, and hypervigilant attention (Berkman et al., 2009; Bijttebier, Beck, Claes, & Vandereycken, 2009; Johnson et al., 2003).

Sensitivity to reward and punishment is normally distributed, and extreme values are associated with an increased risk for psychological disorders (Bijttebier et al., 2009; Kimbrel, Nelson-Gray, & Mitchell, 2007; Nelson-Gray et al., 2007; Pickering & Gray, 1999). Heightened BAS reactivity has been found in bipolar disorder (Bijttebier et al., 2009), attention-deficit/hyperactivity disorder (Bijttebier et al., 2009; Johnson et al., 2003; J. Taylor, Reeves, James, & Bobadilla, 2006), bulimia (Bijttebier et al., 2009), substance abuse disorders (Bijttebier et al., 2009; Franken, Muris, & Georgieva, 2006; Johnson et al., 2003; Kimbrel et al., 2007; J. Taylor et al., 2006), antisocial personality disorder (Quay, 1993; J. Taylor et al., 2006), and histrionic personality disorder (J. Taylor et al., 2006). Other studies have found especially low BAS reactivity in anhedonic depression (Bijttebier et al., 2009; Kasch et al., 2002; Kimbrel et al., 2007). High BIS reactivity has been found in anxiety disorders (Bijttebier et al., 2009; Johnson et al., 2003; Kimbrel et al., 2007), depression (Bijttebier et al., 2009; Johnson et al., 2003; Kasch et al., 2002; Kimbrel et al., 2007), anorexia, bulimia (Bijttebier et al., 2009; Monteleone, Scognamiglio, Monteleone, Perillo, & Maj, 2014), and Cluster C personality disorders (Nelson-Gray et al., 2007; Ross et al., 2013).

BORDERLINE PERSONALITY DISORDER

The impulsive behaviors characteristic of BPD suggest that individuals with this disorder would be highly sensitive to reward and have difficulty resisting behaviors associated with immediate reward and relief (American Psychiatric Association [APA], 2013). Consistent with this idea, those with BPD responded strongly to the immediacy of reward in delay discounting tasks, preferring a smaller immediate reward to a larger delayed one (Berenson et al., 2016; Lawrence, Allen, & Chanen, 2010). In addition, neuroimaging studies have found a physiological basis for impulsivity in BPD, characterized by low feedback-related negativity (FRN) amplitude and hyperactivity in the mesolimbic dopaminergic system (Vega et al., 2013; Vollum et al., 2007).

At the same time, it also makes sense that BPD would be associated with sensitivity to punishment (Vollum et al., 2007) given that invalidating (punishing) environments are thought to contribute to the development of this disorder in combination with heritable traits of emotion dysregulation (Carpenter, Tomko, Trull, & Boomsma, 2013; Linehan, 1993; Nelson-Gray et al., 2007). Indeed, several studies have also shown elevations in self-reported levels of BIS reactivity in BPD (Kobleva et al., 2014; Nelson-Gray et al., 2007; Pastor et al., 2007; Ross et al., 2013; Soler at al., 2014; J. Taylor et al., 2006). Interestingly, studies of BPD have also found decreased sensitivity to punishment in the context of reward (Kirkpatrick et al., 2007) and strong emotions (Dixon-Gordon, Tull, Hackel, & Gratz, 2017). Therefore, while people with BPD may be high in trait sensitivity to both reward and punishment, reactivity to reward may be predominant in situations that engage both systems.

AVOIDANT PERSONALITY DISORDER

The tendency of individuals with APD to withdraw from social relationships that they strongly desire in order to avoid rejection (APA, 2013) suggests that they may be more sensitive to punishment than to reward. Consistent with this prediction, self-reported BIS reactivity is correlated with self-reports of socially anxious and avoidant tendencies, and with Cluster C personality disorders as a whole (Nelson-Gray et al., 2007). However, to our knowledge no previous studies have specifically examined sensitivity to reward and punishment in APD.

BEHAVIORAL ASSESSMENT OF REWARD AND PUNISHMENT SENSITIVITY

Reward and punishment sensitivity can be assessed with a variety of behavioral tasks involving uncertainty, reward–punishment contingencies, and reward-based learning capacities. Tasks such as the Passive Avoidance Learning (PAL) task, the Probabilistic Reversal Learning (PRL) task, the Iowa Gambling task, and the Wheel of Fortune task come close to modeling real-life decision making. Although only some of these tasks have been employed in diagnosed BPD samples (and none in diagnosed APD samples), they have been employed in samples that vary in characteristics relevant to these disorders, such as impulsivity, trait anxiety, and social anxiety.

Researchers have used behavioral tasks to examine BPD and, more generally, the tendency to act without anticipating the consequences. The PAL task assesses the capacity to learn stimulus–reward and stimulus–punishment contingencies by measuring the capacity to respond to a stimulus to obtain a reward and the ability to inhibit response to avoid punishment (Newman, 1987). In one study (Hochhausen, Lorenz, & Newman, 2002), incarcerated women diagnosed with BPD made more errors of commission and fewer errors of omission on the PAL task than incarcerated women without BPD; notably, errors of commission on the task were also associated with self-reports of impulsive, dysregulated behaviors. A subsequent study of passive avoidance learning in a community sample similarly found elevated errors of commission in individuals with BPD features (Chapman, Leung, & Lynch, 2008). Individuals with BPD are also distinguished by difficulties learning from negative feedback to avoid punishment on the Iowa Gambling task (Haaland & Landrø, 2007; Schuermann, Kathmann, Stiglmayr, Renneberg, & Endrass, 2011).

Impulsive responding has also been associated with decreased ability to flexibly adapt behavioral choices in response to varying stimulus–reward contingencies (Franken, van Strien, Nijis, & Muris, 2008) as assessed in the PRL task (Cools, Clark, Owen, & Robbins, 2002). Berlin, Rolls, and Iversen (2005) employed a probabilistic reversal task to study impulsivity in BPD inpatients and individuals with orbitofrontal cortex lesions relative to healthy individuals. Although the two clinical groups showed similar levels of self-reported impulsive behaviors, only individuals with lesions in the orbitofrontal cortex failed to switch their response on PRL trials that followed large monetary losses significantly more often than healthy individuals. Because their performance on the PRL task was not significantly impaired for individuals with BPD relative to healthy individuals, Berlin et al. (2005) suggested that perhaps impulsive behaviors in BPD are better explained by vulnerability to emotionally driven responding than by insensitivity to punishment per se.

A few studies have examined psychological problems involving excessive inhibition using behavioral tasks as well. On the Iowa Gambling task, trait anxiety is associated with a deficit in risk-taking behavior, such that highly anxious individuals avoid choices that are likely to be rewarded, in order to avoid the additional anxiety associated with the potential for punishment (Miu, Heilman, & Houser, 2008). In fact, because highly anxious individuals are characteristically biased to expect negative outcomes (Cabeleira et al., 2014), they exhibit risk aversion even when the probability of punishment is objectively low (Charpentier, Aylward, Roiser, & Robinson, 2017; Giorgetta et al., 2012, Raghunathan & Pham, 1999). During a probabilistic learning task (Jiang et al., 2018), individuals with high trait anxiety learned the stimulus–reward contingencies slower than individuals with low trait anxiety, because after receiving some initial negative feedback they stopped allocating sufficient attention to feedback to effectively learn from it. Social anxiety has similarly been associated with risk aversive behavior on the Wheel of Fortune task, including slower response times and placing fewer bets that carry a potential for loss (Richards et al., 2015).

THE CURRENT RESEARCH

In this study, we examined responses to reward and punishment in community adults diagnosed with BPD or APD, relative to a healthy comparison (HC) group, using a self-report measure (the Sensitivity to Punishment and the Sensitivity to Reward Scales) and two behavioral tasks: Passive Avoidance Learning (PAL), and Probabilistic Reversal Learning (PRL).

We predicted that relative to the HC group, the BPD group would have higher scores on self-report measures of both reward and punishment sensitivity, as well as higher reward sensitivity in the behavioral tasks. We predicted that the high punishment sensitivity associated with BPD may not be evident during the behavioral tasks, because among highly reward-sensitive individuals, opportunities for reward appear to lower and override sensitivity to punishment when both systems are engaged simultaneously. We predicted that the APD group, compared to the HC group, would show lower sensitivity to reward and higher sensitivity to punishment, in both the self-report and behavioral assessments. Finally, we hypothesized that compared to the APD group, the BPD group would show higher self-reported sensitivity to reward and no significant difference in self-reported sensitivity to punishment. On behavioral tasks, the BPD group would show higher sensitivity to reward and lower sensitivity to punishment, relative to the APD group.

METHOD

PARTICIPANTS AND RECRUITMENT

This study was part of a larger project for which we have previously published the participant recruitment procedures (Gadassi, Snir, Berenson, Downey, & Rafaeli, 2014) and participant characteristics (Berenson et al., 2018). After a telephone prescreening, adults from a U.S. urban community completed the Structured Interview for the Diagnosis of Personality Disorders (SID-P-IV; Pfohl, Blum, & Zimmerman, 1997) and the Structured Clinical Interview for *DSM-IV* Axis I Disorders (SCID-I; First, Gibbon, Spitzer, & Williams, 1996). Interrater reliability estimates (average kappas) for the interviews were .83 for personality disorders and .86 for Axis I disorders. All participants provided written informed consent, and all study procedures were approved by the applicable institutional review board.

In order to recruit BPD and APD samples generalizable to the population of individuals who carry these diagnoses, who often have complex psychiatric histories (e.g., Dolan-Sewell, Krueger, & Shea, 2001; Shea et al., 2004), we used few exclusion criteria. Participants were not excluded from the BPD or APD groups for use of psychotropic medication, or for other coexisting disorders. Participants who met criteria for both BPD and APD were included in the BPD group. The HC group was required to meet fewer than three criteria for any specific personality disorder (and fewer than 11 criteria in total), have no psychiatric diagnoses or psychotropic medication use for at least 1 year prior to the interview, and have a Global Assessment of Functioning (GAF; APA, 2000) score above 79. Participants eligible for the APD group were required to meet criteria for APD and to not meet criteria for any Cluster B personality disorder. Primary psychotic disorder, current substance intoxication or withdrawal, and cognitive impairment or illiteracy were exclusion criteria for all three groups.

In total, 173 participants completed the measures that are the focus of this article. The BPD group included 64 participants (51 women). Sixteen participants (12 women) in the BPD group also met criteria for APD. The APD group included 49 participants (26 women), and the HC group included 60 participants (43 women). The APD group included a significantly higher percentage of men than the other two groups, $\chi^2(3, N = 173) = 9.49, p = .009$.

Participants were aged 18–64 years ($M = 32.12$, $SD = 10.60$). They identified as White (47.4%), Black (21.4%), Hispanic/Latino (15.0%), Asian (10.4%), and other/multiple backgrounds (5.8%). There were no between-group differences in age or race/ethnicity. Participants had completed between 10 and 20 years of education ($M = 16.08$, $SD = 2.7$), with the HC group completing more years ($M = 17.3$) than the BPD and APD groups ($M = 15.3$ and $M = 15.6$, respectively), $F(3, N = 173) = 11.03, p < .001$. At the time of their interview, 95.6% of participants in the BPD and APD groups also met criteria for *DSM-IV* Axis I diagnoses (for details, see Berenson et al., 2018).

The vast majority of participants in the BPD and APD groups had received mental health treatment in the past (93.8% for BPD, 85.7% for APD). Most participants in the BPD (68.8%) and APD (57.1%) groups were currently receiving treatment with psychotropic medications and/or psychotherapy, and treatment utilization was not significantly associated with interviewer ratings of functioning (GAF), age, or gender in either group. For participants in the BPD group, currently receiving treatment was inversely associated with meeting criteria for a current major depressive episode ($r = -.47, p < .001$), although it was not significantly associated with any other Axis I disorder, or with the number of criteria met for any personality disorder. Treatment utilization in the BPD group was also associated with a higher education level ($r = .27, p = .030$) and identifying as White ($r = .34, p = .006$). Within the APD group, current treatment was negatively associated with the number of APD criteria met ($r = -.29, p = .042$) and positively associated with full-time employment ($r = .35, p = .013$), but it did not vary with any other personality disorder, Axis I disorder, education, or race/ethnicity.

PROCEDURE

The laboratory tasks that are the focus of this article were administered during participants' third and final visit to the lab, after they had completed interviews, a questionnaire packet, laboratory tasks, and experience-sampling diaries over a period of several weeks. The tasks were programmed with

Empirisoft software and presented on a computer with a response box. Data from the questionnaires and laboratory tasks reported here have not been reported in any previous publications.

MATERIALS

Self-Reported Sensitivity to Reward and Punishment. The Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ; Torrubia, Ávila, Moltó, & Caseras, 2001) consists of a series of questions that participants answer *true* or *false*. The 24-item Sensitivity to Reward subscale assesses impulsivity in regard to attaining a reward, such as money, social events, sex partners, power, and sensation; for example: "Do you sometimes do things for quick gains?" Internal consistency in this sample was .82. The 24-item Sensitivity to Punishment subscale measures avoidance of situations with potentially negative consequences and worry caused by threat of punishment or failure; for example: "Do you, on a regular basis, think that you could do more things if it was not for your insecurity or fear?" Internal consistency in this sample was .93.

Passive Avoidance Learning Task. As a behavioral measure of reward responsivity and response inhibition, participants completed a PAL task based on that of Newman and Schmitt (1998). Each trial began with the presentation of a cue associated with either a 10-point gain or a 10-point loss. Stimuli were presented one at a time on the screen until participants responded or 3 s had passed. At each presentation, participants could either make no response or respond by pressing a button. Each button press resulted in feedback indicating the participant had either won or lost, depending on the stimulus. Half the stimuli were associated with gains and half with loss. Pressing the button in response to cues associated with winning resulted in a high-pitched tone and feedback on the monitor that said, "YES! You won 10 points." Button presses in response to cues associated with losing resulted in a low-pitched tone and feedback that said, "You LOSE 10 points." No feedback was given, and no points were won or lost when the participant did not respond. The experimenter kept a running total of the score in full view of the participant.

We instructed participants to use trial and error to learn when to respond and when not to respond, as well as to maximize their score by pressing in response to gain cues and by refraining from pressing in response to loss cues. Experimental stimuli consisted of 10 two-digit numbers identical to those of Newman and Schmitt (1998). To ensure that they understood the instructions, participants first completed a practice phase using letters as stimuli. The PAL task began with a five-trial reward pretreatment, in which each winning cue was presented on screen. The pretreatment served to establish a pattern of active responding that the participant must subsequently learn to inhibit and replace with passive avoidance. The 70 test trials immediately followed the pretreatment. Test trials consisted of seven blocks, during which the 10 stimuli were presented in random order. Performance was indexed by two types of errors: failures to inhibit responses to loss cues (commission errors), and failures to respond to winning cues (omission errors).

Probabilistic Reversal Learning Task. Participants completed a PRL task based on Hornak et al (2004). The PRL task is a visual discrimination task based on the ability to flexibly and strategically adapt to changes in environmental contingencies. Each trial consisted of the presentation of two abstract patterns side-by-side on the computer screen. The task was self-paced, such that trials lasted until the participant selected one of the two patterns by pressing the button corresponding to the pattern's location on the screen (left or right). Stimulus locations were randomized. Selecting each pattern resulted in visual feedback signaling the gain or loss of varying amounts of points. Participants began with 0 points, and the experimenter kept a running total of the score in full view of the participant.

The reinforcement contingencies were probabilistic, such that the participant could gain or lose points by choosing either pattern, but one pattern was more profitable than the other overall. Choosing the correct pattern yielded gains on 70% of the trials and losses on 30% of the trials, while the incorrect pattern yielded gains on 40% of the trials and losses on 60% of the trials. Not only did the correct pattern yield a higher probability of gains, but it also yielded larger gains and smaller losses than the incorrect pattern. Gains for the correct pattern ranged from 8 to 25 points and losses from 1 to 6 points. For the incorrect pattern, gains ranged from 1 to 7 points and losses from 25 to 60 points.

Participants first completed a pretest acquisition phase with a separate pair of abstract stimuli. This practice phase served to provide experience with the 70-30 and 40-60 gain-loss contingencies, but it utilized a different amount of gains (6 to 20 for the correct stimulus, 1 to 10 for the incorrect stimulus) and losses (1 to 5 for the correct stimulus, 7 to 30 for the incorrect stimulus) than the test trials. The practice phase required participants to learn which pattern was more profitable overall by trial and error and culminated when participants chose the correct stimulus on 10 of 12 consecutive trials.

Participants then read instructions explaining that in the next phase of the task, a reversal would gradually occur once they had consistently chosen the "good" pattern. Participants were instructed to monitor which pattern was currently the more profitable choice and to choose it consistently in order to gain as many points as possible until a reversal occurred, at which point they should adjust their choice accordingly. Reversals began when participants chose the correct stimulus in 9 of 10 trials and involved the gradual shift of reinforcement contingencies in stepwise fashion over the next 10 trials, such that with each trial, the probability of gains/losses shifted, as did the potential quantity of gains/losses. By the 10th trial, the reversal was completed. The task consisted of 80 test trials. General performance was indexed with a total score and number of reversals completed. The variables of primary interest were the strategies employed during the task, namely, the percent of times participants stayed with their choice after winning points (win-stay strategy) or switched their choice following losses (lose-shift strategy).

RESULTS

We examined diagnostic group differences in our measures of sensitivity to reward and punishment in a series of analyses of covariance (ANCOVAs). Group (BPD, APD, HC) was the between-subjects factor, and both gender and age were covariates.

SELF-REPORTED SENSITIVITY TO REWARD AND PUNISHMENT

For sensitivity to reward, a significant effect of diagnostic group emerged, $F(2, 168) = 10.57$, $p < .001$, $\eta_p^2 = .112$. The BPD group ($M = 11.77$, $SE = .58$) demonstrated significantly higher sensitivity to reward relative to both the APD group ($M = 9.13$, $SE = .66$), $t(168) = 2.96$, $p = .004$, and the HC group ($M = 8.08$, $SD = .59$), $t(168) = 4.49$, $p < .001$. The APD and HC groups did not significantly differ from one another, $t(168) = 1.18$, $p = .238$. There were also significant diagnostic group differences in sensitivity to punishment, $F(2, 168) = 177.50$, $p < .001$, $\eta_p^2 = .679$, such that both the BPD ($M = 15.82$, $SE = .53$) and APD ($M = 19.32$, $SE = .61$) groups reported significantly higher sensitivity to punishment than the HC group ($M = 5.06$, $SE = .54$); $t(168) = 14.26$, $p < .001$, and $t(168) = 17.48$, $p < .001$, respectively. The APD group also reported significantly higher sensitivity to punishment than the BPD group, $t(168) = 4.28$, $p < .001$.

PASSIVE AVOIDANCE LEARNING

To assess group differences in passive avoidance learning, we conducted a 2 × 3 mixed-model ANCOVA with Error Type (omission errors, commission errors) as the within-subjects factor and Group (BPD, APD, HC) as the between-subjects factor. (Note: One BPD group participant was excluded due to experimenter error.) There was a significant main effect of Error Type, $F(1, 167) = 14.79$, $p < .001$, $\eta_p^2 = .081$, such that, across groups, participants made significantly more commission errors than omission errors. This main effect was qualified by a Group × Error Type interaction, $F(2, 167) = 6.18$, $p = .003$, ${\eta_p}^2 = .069$.

Follow-up tests showed that, as predicted, the BPD group made significantly fewer omission errors ($M = 3.51$, $SE = .49$) than the HC group ($M = 5.19$, $SE = .49$), $t(167) = -2.42$, $p = .016$. The number of omission errors made by the APD group ($M = 4.35$, $SE = .56$) did not differ significantly from the number made by the BPD group, $t(167) = 1.11$, $p = .268$, or the HC group, $t(167) = -1.13$, $p = .260$. The BPD group made significantly more errors of commission ($M = 12.14$, $SE = .60$) than the HC group ($M = 9.91$, $SE = .61$), $t(167) = 2.60$, $p = .010$, as predicted. However, an unexpected finding was that the APD group ($M = 11.90$, $SE = .69$) also made more commission errors than the HC group, $t(167) = 2.15$, $p = .033$. The number of commission errors made by the BPD and APD groups did not differ significantly, $t(167) = .257$, $p = .797$.

Next, we considered potential confounding variables. Because reward sensitivity has been inversely associated with depression and positively associated with antisocial traits (Harmon-Jones & Allen, 1997; Hochhausen et al., 2002; Shankman, Klein, Tenke, & Bruder, 2007), we conducted supplementary ANCOVAs excluding participants in a current episode of unipolar depression and (in a separate analysis) participants presenting any symptom of antisocial personality disorder. In both analyses, all previously reported findings remained significant, indicating that the diagnostic group differences are not better explained by co-occurring depression or antisociality.

PROBABILISTIC REVERSAL LEARNING

Hypothesizing that the APD group would demonstrate greater sensitivity to losses by shifting their choice more often following a loss relative to the HC group, we calculated the percentage of trials in which participants shifted strategy after all trials involving losses, and the percentage of trials in which participants maintained their strategy after all trials involving gains. The ANCOVAs we conducted to examine group differences excluded one participant who did not achieve the learning criterion during the pretask acquisition trials and 20 participants (12 BPD, 2 APD, 6 HC) who were not given the opportunity to reach criterion due to experimenter error.

A significant effect of diagnostic group, $F(2, 142) = 3.64$, $p < .029$, $\eta_p^2 = .049$, showed that, as predicted, the APD group ($M = .826$, $SE = .029$) demonstrated significantly higher reactivity to losses relative to both the BPD ($M = .728$, $SE = .027$), $t(1, 142) = 2.42$, $p = .018$, and the HC groups ($M = .734$, $SD = .026$), $t(1, 142) = 2.35$, $p = .020$. Thus, while participants typically responded to losses by switching their choice, losses had greater predictive power with respect to the participants' subsequent response for the APD group. When we conducted the same ANCOVA on the degree to which gains prompted participants to maintain their strategy, we found no significant group differences, $F(2, 142) = 2.304$, $p < .104$, $\eta_p^2 = .031$.

ASSOCIATIONS AMONG MEASURES

We examined associations among the self-reported and behavioral indices of reward and punishment sensitivity through partial correlations with age and gender as covariates (see Table 1). While self-reported sensitivity to reward was not significantly correlated with any behavioral measures, self-reported sensitivity to punishment was significantly associated with three of them. Individuals who reported higher sensitivity to punishment pressed losing numbers more frequently during the PAL task. On the PRL task, they were more likely to switch their choice after a loss, and less likely to stick with their choice after a win.

DISCUSSION

The current study examined reward and punishment sensitivity in BPD and APD using both self-report and behavioral measures. We hypothesized that relative to a healthy comparison group, the BPD group would show significantly

TABLE 1. Partial Correlations Among Measures, Controlling for Gender and Age

	1	2	3	4	5
1. Sensitivity to reward (SPSRQ)	—				
2. Sensitivity to punishment (SPSRQ)	.280*	—			
3. Errors of omission (PAL)	−.101	−.112	—		
4. Errors of commission (PAL)	.046	.204*	−.111	—	
5. Switch after loss (PRL)	−.009	.175*	−.147	−.044	—
6. Stay after gain (PRL)	−.030	−.181*	−.094	−.203*	.070

Note. SPSRQ = Sensitivity to Punishment and Sensitivity to Reward Questionnaire; PAL = Passive Avoidance Learning task; PRL = Probabilistic Reversal Learning task. $^*p < .05$.

higher sensitivity to both reward and punishment, while the APD group would show significantly lower sensitivity to reward and higher sensitivity to punishment. We also hypothesized that relative to the APD group, the BPD group would show higher sensitivity to reward but no significant difference in sensitivity to punishment. Our hypotheses were fully supported by the results from the self-report measures of reward and punishment sensitivity but only partly supported by the results from behavioral measures of these constructs.

As predicted, the BPD group exhibited higher sensitivity to reward than the HC group, indexed by fewer errors of omission and more errors of commission on the PAL task, even when considering possible confounds that could explain the differences between groups (Harmon-Jones & Allen, 1997; Shankman et al., 2007). In addition to supporting our hypotheses, these findings replicate prior research showing more errors of commission and fewer errors of omission on the PAL task in incarcerated women with BPD, showing that these patterns also hold true in a more generalizable community sample with BPD (Hochhausen et al., 2002).

Interestingly, although the BPD group showed elevated sensitivity to punishment as assessed through self-report, the BPD group's sensitivity to punishment during the PRL task was significantly lower than that of the APD group and not significantly different from that of the HC group. Although unpredicted, this result is consistent with prior research suggesting that sensitivity to punishment is context-dependent in individuals with BPD, and that it is low in the context of opportunities for reward (Kirkpatrick et al., 2007).

As predicted, the APD group shifted their choice significantly more often than the other two groups following losses on the PRL task, demonstrating higher reactivity to punishment. This finding complements prior evidence of high behavioral sensitivity to loss and punishment in individuals with high trait anxiety (Jiang et al., 2018; Miu et al., 2008) and high social anxiety (Richards et al., 2015), both constructs associated with APD. Interestingly, this finding implies that participants in the APD group had associated punishment with an abstract, nonsocial stimulus, and actively avoided it by switching their choice—consistent with early theoretical conceptions of APD (Arntz, 1999; Rettew, 2000; Widiger, 2001) as well as empirical findings (C. T. Taylor, Laposa, & Alden, 2004) suggesting that avoidance in APD extends beyond avoidance of social situations to nonsocial situations that involve novelty and risk of unpleasant emotions.

Unexpectedly, the APD group demonstrated significantly more errors of commission than the HC group on the PAL task. We speculate that perhaps this may be explained by the high levels of anxiety that individuals with APD may have experienced during the PAL task, because it involved a prolonged social interaction with the experimenter in the testing room. Exposure to social stress has been shown to make socially anxious individuals more prone to commit mistakes and engage in impulsive behaviors, compared to individuals with lower social anxiety (Richards et al., 2015). In other words, it is possible that the high rate of errors of commission we observed in the APD group on the PAL task reflects responses to the experimenter's presence rather than lower sensitivity to punishment or higher sensitivity to reward.

One limitation of this study is that we utilized measures based on Gray's (1987) original Response Sensitivity Theory, rather than the updated conceptualization. Although BIS is now thought to be activated by conflict (i.e., a mismatch between response and outcome) rather than punishment and the Fight-Flight-Freeze system is thought to account for sensitivity to punishment (Gray & McNaughton, 2000), no measures have been developed to differentiate between the Fight-Flight-Freeze system and the BIS (Bijttebier et al., 2009). Revised measures should be developed and used to clarify which system is responsible for punishment sensitivity.

Although the behavioral measures we used offer advantages over self-report measures, they also have limitations. Both our PAL and PRL tasks were administered with points rather than actual gains and losses of monetary value, and therefore have less external validity than more realistic tasks involving gambling or risky behavior. Also, as previously noted, it is possible that the experimenter's presence in the testing room introduced a social element to the tasks that we had not anticipated, and this may have especially caused anxiety for those in the APD group. Future research may benefit from assessing behavioral measures in a noninterpersonal manner. Alternatively, to the extent that sensitivity to reward and punishment may vary with emotional context (Dixon-Gordon et al., 2017), it may make sense to manipulate the context in which these tasks are given, for example, by including a stress-induction condition.

Our sample can be considered both a limitation and a strength for the generalizability of our results. Participants with BPD and APD were recruited from the community with minimal exclusion criteria, and therefore are representative of the heterogeneity associated with these disorders in demographic characteristics, comorbid disorders, and treatment experiences/needs. Relative to participants in outpatient clinical samples, participants in our study were less likely to have received a targeted treatment for their personality disorder, or to understand that they had disorders for which treatment is possible. When compared to the participants who were receiving medication and/or psychotherapy, those who were not currently in treatment faced equal or greater symptom severity and impairment; socioeconomic and sociocultural factors also appeared likely to have played a role in treatment underutilization. We note that a quarter of participants in the BPD group also had APD. In addition, participants with subclinical features of APD were included in the BPD group, and participants with subclinical features of BPD were included in the APD group. Given that the presence of overlapping symptoms in our BPD and APD groups is likely to have reduced our ability to find differences between them, the fact that we selected our sample to have real-world generalizability rather than artificial diagnostic purity makes the statistically significant differences we found even more compelling.

Largely consistent with the existing theory and research suggesting an imbalance in BIS/BAS reactivity in BPD and APD (e.g., Gray, 1987; Gray & McNaughton, 2000; Nelson-Gray et al., 2007; Soler et al., 2014), our results contribute to this literature by directly testing whether the predicted differences between these disorders emerge in both real behavior and self-report measures. Basic research findings on how sensitivity to reward and punishment contribute to and reinforce the features that cause distress and impairment in APD, BPD, and other disorders may allow us to develop effective interventions that target this sensitivity (such as behavioral activation as a treatment for depression). Such interventions may help alleviate the distress and impairment caused by these disorders and may even help reduce the personal, economic, and societal costs of personality disorders.

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