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Perception of Facial Emotion in Adults with Bipolar or Unipolar Depression and Controls

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Abstract

Previous research indicates that patients with depression display deficits in their ability to perceive emotions. However, few studies have used animated facial stimuli or explored sensitivity to facial expressions in depressed individuals. Moreover, limited research is available on facial processing in unipolar versus bipolar depression. In this study, 34 patients with DSM-IV major depressive disorder (MDD), 21 patients with DSM-IV bipolar disorder (BPD) in the depressed phase, and 24 never-depressed controls completed the Emotional Expression Multimorph Task, which presents facial emotions in gradations from neutral to 100% emotional expression (happy, sad, surprised, fearful, angry, and disgusted). Groups were compared in terms of sensitivity and accuracy in identifying emotions. Our preliminary findings suggest that subjects with bipolar depression may have emotional processing abnormalities relative to controls.

Keywords

Bipolar disorder (BPD); cognition; facial expression; emotion perception; unipolar depression

1. Introduction

Depression is associated with impairments in judging facial expressions, a crucial part of social interaction. Such deficits may offer an explanation for the decreased psychosocial functioning that many people with depression experience as their symptoms become more severe (Judd et al., 2005; Judd et al., 2000). Previous studies noted that patients with unipolar and bipolar depression are less accurate than controls at identifying facial expressions (Derntl et al., 2009; Gray et al., 2006; Gur et al., 1992; Leppanen et al., 2004; Persad and Polivy, 1993; Rubinow and Post, 1992; Surguladze et al., 2004), an impairment that could be due to difficulty attending to salient facial features when viewing faces (Loughland et al., 2002).

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Several studies have indicated that these deficits reflect a negative bias in perception, where happy faces are interpreted as neutral, and neutral faces are interpreted as sad (Gur et al., 1992; Leppanen et al., 2004; Surguladze et al., 2004; Yoon et al., 2009). Subjects with unipolar depression also appear to be slower to detect positive facial expressions than healthy volunteers (Suslow et al., 2004). Moreover, the way that patients view negative emotions corresponds with the course of their illness. Individuals with unipolar depression who perceive high levels of negative emotions when viewing faces tend to have a course of illness characterized by greater severity of depression, persistence of symptoms, and likelihood of relapse (Bouhuys et al., 1999; Hale, 1998). However, one study found that even after remission, patients with a history of recurrent depression displayed impaired sensitivity to happy faces as compared to controls (LeMoult et al., 2009).

In terms of bipolar disorder (BPD), studies have found that patients are less accurate at identifying certain emotions. For instance, subjects with BPD were less accurate than controls in identifying surprised (Bozikas et al., 2007; Summers et al., 2006) and fearful facial expressions (Bozikas et al., 2007). Other studies found generalized deficits in recognizing expressions as opposed to emotion-specific impairments. Subjects with bipolar depression were less accurate at identifying emotional expressions overall as compared to controls, (Gray et al., 2006). In addition, generalized impairments were found in euthymic BPD patients as well, suggesting a trait deficit in emotional processing (Bozikas et al., 2006; Derntl et al., 2009).

Traditionally, tasks that assess emotion perception use static facial stimuli representing happy, sad, and neutral expressions. These tasks, however, fail to emulate the range of emotions and the varying intensity of expression that people experience in real-life situations. Preliminary evidence suggests that tasks incorporating a wider variety of facial expressions reveal a deficit across emotions (Asthana et al., 1998; Persad and Polivy, 1993). Recently, researchers started to use forms of animated facial stimuli displaying various intensities, providing a more realistic and sensitive measure of emotion perception (Gray et al., 2006; Rich et al., 2008b; Summers et al., 2006; Venn et al., 2004).

Animated facial stimuli allow researchers to measure sensitivity to facial expressions, which represents an important aspect of social interaction. While several studies have explored sensitivity in BPD, very few have used animated facial stimuli with unipolar depression. Preliminary findings for BPD indicate that euthymic adults do not display impaired sensitivity (Venn et al., 2004); however, during the depressed phase of BPD, patients exhibited reduced sensitivity in recognizing certain emotions (Gray et al., 2006; Summers et al., 2006). However, findings have been inconsistent regarding which emotions are pertinent to this deficit. Although a reduced sensitivity to happiness is consistently reported, the results vary for negative emotions. One study found no deficit for negative emotions (Gray et al., 2006), whereas another study discovered a deficit in identifying disgusted and fearful faces, but not sad faces (Rich et al., 2008b). Summers and colleagues (2006) found that a group of individuals with bipolar depression were less likely to identify angry faces than the euthymic BPD group. Given the variation in findings, more research is clearly needed to decipher the nature of the deficit.

Although most studies exploring sensitivity to facial expressions have been conducted in individuals with BPD, preliminary results suggest deficits in this area for Major Depressive Disorder (MDD) as well. Gur and colleagues (1992) found that BPD and MDD subjects with higher negative affect displayed more impaired sensitivity to sad faces. Surguladze and colleagues (2004) found that individuals with MDD tended to mislabel mildly happy faces. However, these studies used static as opposed to animated facial expressions, which might influence the nature of the results. To our knowledge, few studies have compared the

perception of facial emotion in individuals with unipolar versus bipolar depression, and the studies that included both unipolar and bipolar participants did not analyze the data separately for each diagnostic group (Gur et al., 1992; Rubinow and Post, 1992).

This study used animated facial stimuli to compare the accuracy and sensitivity of emotion perception between individuals with unipolar and bipolar depression as well as controls. We hypothesized that the MDD and BPD groups would exhibit an overall decreased sensitivity to emotional faces compared to controls. Moreover, we predicted that these groups would be less accurate than the control group when labeling emotions.

2. Materials and Methods

2.1. Subjects

Participants were recruited from ongoing studies at the National Institute of Mental Health (NIMH). The subjects met DSM-IV criteria for MDD ($n=34$) or BPD I or II, depressed phase ($n=21$) as determined by the Structured Clinical Interview for Axis I DSM-IV Disorders—Patient Version (SCID-P) (First et al., 2001). All participants were free of acute medical illnesses, current psychotic features, and substance abuse or dependence for the past three months. The subjects with unipolar depression and one subject with BPD were medication-free for approximately two weeks before testing. All other subjects with bipolar depression were receiving therapeutic doses of lithium or valproic acid for at least three weeks before testing. Twenty-four healthy subjects were recruited through advertisements on campus and in local newspapers and underwent a screening visit at the NIMH that included a medical history and physical exam performed by a physician and a Structured Clinical Interview for DSM-IV, non-patient version. Healthy control subjects had no current or past psychiatric or neurological illness, substance abuse, a family history of psychiatric illness, or medical conditions that could affect cognitive performance. All SCID interviews were administered by trained clinicians with high inter-rater reliability ($\kappa=.93$).

2.2. Procedures

The Montgomery-Åsberg Depression Rating Scale (MADRS) was administered by trained clinicians to all participants in order to assess the severity of depression (Montgomery and Åsberg, 1979). The Young Mania Rating Scale (YMRS) was administered by trained clinicians to the MDD and BPD groups to assess manic symptoms (Young et al., 1978). Inter-rater reliability was high for both scales (MADRS: $\text{ICC}=.95$; YMRS: $\text{ICC}=.97$). In order to assess IQ, all participants completed the matrix reasoning and vocabulary subtests of the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999). The study was approved by the Combined Neuroscience Institutional Review Board at the National Institutes of Health (NIH). All participants gave written informed consent after receiving a detailed explanation of the study.

All participants completed the Emotional Expression Multimorph Task, the same task administered by Rich and colleagues (2008), as well as a variation of the task created by Blair and colleagues (2001). Happy, sad, angry, disgusted, surprised, and fearful faces from Eckman and Friesen's (1976) Pictures of Facial Affect were used as the facial stimuli. The faces were displayed on a computer screen and slowly morphed through 39 iterations from neutral intensity (0%) to full emotional intensity (100%). Each iteration lasted 100 milliseconds. Six different faces (three female) each displayed the six different emotions in random order for a total of 36 trials.

Participants were asked to watch the screen and inform the administrator as soon as they recognized the expression without merely guessing. The administrator then pressed a "stop" button that froze the face, and the subject selected the emotion from the six options listed at

the bottom of the screen. The face then continued to morph through the remaining iterations. When the face reached 100% intensity, participants were asked to verify their response. Subjects could also change their answer at any point throughout the morph.

2.3. Statistics

The primary outcome measure was the morph level at which the subject identified the facial emotion; higher numbers indicated response to a stimulus with less emotional intensity. Three types of these measures were examined: the level at first response, correct response where incorrect items were listed as missing, and correct response where incorrect items were given one below the lowest possible value, or 0. The latter measure was included to understand whether results would change substantially with a type of censored outcome in cases where a correct response was not provided. An additional outcome measure was accuracy, as calculated by the percentage of correct responses.

Linear mixed models with compound symmetry covariance structures and restricted maximum likelihood estimation were used in full factorial models to examine the effects of diagnosis, emotion, and the trial number for each emotion. Only the fixed intercept was included in the models. Diagnoses included BPD, MDD, and control groups. Emotion (happy, sad, surprised, angry, disgusted, and fearful) and trial number (1 to 6) were within-subjects factors. Trial number for each emotion was included to evaluate potential learning effects through the course of the task. An additional model with factors for diagnosis and emotion examined the proportion of correct responses. Further, models covarying for age, IQ, gender, and depression severity (MADRS) were examined separately, where depression was used with the patient groups only. Bonferroni post hoc tests were used following significant effects. Significance was evaluated at $p < .05$, two-tailed. SPSS 17.0.3 was used for all analysis (SPSS, Inc, Chicago, Illinois).

Group comparisons of demographic factors used one-way ANOVAs for continuous measures and chi-square tests for categorical variables. Bonferroni post hoc tests were used with ANOVAs and 2×2 chi-square tests were used to follow up significant omnibus chi-squares.

3. Results

The groups were similar in age, IQ, and sex (see Table 1). As expected, the control group exhibited less depression than the patient groups.

The linear mixed model for the morph level reached on the first response showed significant main effects for diagnosis, emotion, and trial, but no interactions (see Table 2 and Figure 1). The BPD group required a more intense facial expression to make a first response than controls ($p = .03$), but there were no differences between the unipolar and BPD groups ($p = .24$) or between the unipolar group and controls ($p = .78$). Across diagnoses, happy faces were recognized at a significantly less intense expression than the other emotions (all p values $> .001$) and disgusted faces required a lower intensity for first responses than fearful ($p = .02$) and sad ($p < .001$). Also, the second time a face appeared in the series of a given facial emotion required a significantly more intense emotional display than all other times (all p values $< .04$). Effect sizes for group comparisons overall and by emotion are shown in Table 3.

The linear mixed model for the morph level for correct identification of face emotion had significant main effects, but non-significant interactions (see Table 2 and Figure 1). As with the first response, the BPD group required a more intense emotional display to correctly identify the facial emotion when compared to controls ($p = .01$), but not patients with unipolar

depression ($p=.22$). There was no significant difference between the control and unipolar groups ($p=.50$). In general, participants correctly identified happy faces with less intense expressions than the other emotions (all p values $<.001$); they correctly identified surprised, sad, and angry faces with less intense expressions than fearful expressions (all p values $<.001$). In addition, participants required more intense expressions to reach the correct response in the second face of an emotion than with the first, fifth, and sixth faces (all p values $<.01$). When incorrect responses were coded as zero for the level reached, findings were nearly identical to counting these as missing (see Table 2).

The linear mixed model examining the percent of correct responses at the end of testing showed a significant main effect for emotion ($F=20.00$, $df=5,380$, $p<.001$), but no main effect for diagnosis ($F=1.80$, $df=2,76$, $p=.17$) or interaction ($F=1.53$, $df=10,380$, $p=.13$) (see Figure 1). Across diagnoses, participants had a significantly higher percentage of correct responses for happy faces (mean=99.5, $SE=1.9$) than any other faces. Disgusted faces had as significantly lower level of correct responses than any other faces (mean=74.8, $SE=1.9$). A similar analysis was run with the percent of correct responses at the first response with virtually identical results, a significant main effect for emotion ($F=36.31$, $df=5,380$, $p<.001$) but no significant diagnosis main effect ($F=1.37$, $df=2,380$, $p=.26$) nor interaction ($F=1.58$, $df=10,380$, $p=.11$).

Since accuracy could be influenced by the number of morphs used to determine the correct emotion, the mean number of morphs for each emotion was used as a covariate. Since the covariate showed an interaction with emotion and diagnosis together, the covariate was added to the model as a three way interaction with diagnosis and emotion. The linear mixed model showed no main effect of diagnosis ($F=2.05$, $df=2,291$, $p=.13$), but the interaction between diagnosis and emotion was significant ($F=2.85$, $df=10,405$, $p=.002$). Bonferroni post hoc tests examining group differences for each emotion indicated that bipolar patients were significantly more accurate (Mean $\pm$ SE: 97.1 ± 5.5) than unipolar patients (79.6 ± 2.6) ($p=.01$) and healthy controls (81.0 ± 2.9) ($p=.03$) on faces with disgust. There were no other significant differences.

Because correct responses were much higher for happy faces, analyses were rerun without those faces. These results showed the same significant effects as the initial analysis. Adding individual covariates to the linear mixed models for age, gender, IQ, and depression severity, separately, did not alter the original results.

4. Discussion

Our results partially support our first hypothesis, namely that the MDD and BPD groups would display impaired sensitivity to all emotional faces as compared to controls. The BPD group exhibited decreased sensitivity to facial expressions in general compared to controls. Specifically, the BPD group required more intense facial expressions before they first responded, and before they correctly identified the emotion. However, no differences were found between the BPD and MDD groups, or between the MDD and control groups.

Our second hypothesis, that the unipolar and BPD groups would be less accurate than the control group when labeling emotions, was not supported. Results indicated no difference in diagnosis for percentage of correct responses. In fact, when controlling for the average morph level, the BPD group had higher accuracy levels than the MDD and control groups on disgusted faces. Thus, while accuracy levels appear similar across groups at the first and last responses, the BD group appears to respond more accurately on faces with disgust when controlling the number of morphs needed to make an accurate judgment of those faces. This finding is supported by other research that found an enhanced recognition of disgust in the

euthymic phase of BPD as compared to controls (Harmer et al., 2002). Despite previous reports that depression can cause deficits in recognition of emotions from facial expressions, some preliminary findings suggest that moving facial expressions convey enough information for depressed patients to accurately identify emotions (Kan et al., 2004). Moving facial expressions are thought to convey more information about the emotion being represented than the static facial expressions that many previous studies have used. Therefore, differences in the stimuli used could account for the inconsistency between our findings and the previous literature.

To our knowledge, little research has compared adult patients with MDD and BPD with respect to recognition of facial expressions. Rubinow and Post (1992) and Gur and colleagues (1992) studied subjects with MDD as well as participants in the depressed phase of BPD; however, they did not differentiate between the groups. The present study demonstrated an interesting distinction between individuals with unipolar and bipolar depression. Participants with BPD appeared to require a more intense facial expression before they could correctly identify emotions, but when they labeled emotions, they tended to be relatively accurate, particularly with disgust. On the other hand, participants with MDD did not display deficits in terms of intensity of facial expression or accuracy when identifying emotions. Therefore, the BPD and control groups differed in sensitivity, whereas the unipolar and control groups did not, even though both patient groups were depressed. This indicates that sensitivity deficits are not necessarily related to depressive symptoms, since controlling for depression did not change the results. Thus, these differences could reflect a characteristic of BPD. This study supports previous findings that bipolar depression is associated with decreased sensitivity to facial expressions (Gray et al., 2006; Rich et al., 2008b; Summers et al., 2006). More research must be conducted in this area to determine the causes of these group differences. For instance, differences in attention or processing speed were not examined for these patients but could have influenced the outcomes. In addition, a larger sample size might reveal even greater distinctions between these two patient groups. Furthermore, we did not distinguish between BPD I and BPD II due to the small sample size. However, Summers and colleagues (2006) found no difference in emotion processing between these two subgroups, suggesting that individuals with BPD I and BPD II retain similar emotion perception skills.

Our results indicate a general emotional sensitivity deficit in adult bipolar depression. Effect sizes suggest at least low moderate group differences in each of the emotions examined. However, in keeping with previous studies, the largest effect size suggested a possible reduction in sensitivity for happy faces in particular in the BPD group (Gray et al., 2006; Rich et al., 2008b; Summers et al., 2006).

Unlike other studies, we found that individuals with BPD had no deficits in accurately identifying emotions (Gray et al., 2006; Summers et al., 2006); the BPD group was just as accurate as the control and MDD groups and even more accurate for disgusted faces when controlling for the number of morphs. Differences in medication status are unlikely to account for this discrepancy, because the majority of participants in these previous studies were also medicated. However, differences in task administration might be one reason for the inconsistent results. In previous studies, participants viewed the same animated face at least twice, the first time to test accuracy and the second time to test sensitivity (Gray et al., 2006; Summers et al., 2006). This repetition might have created practice effects that could minimize subjects' sensitivity deficits. The strong trial effects in the present study suggest a need to be wary of the number of times an individual has seen a particular type of stimulus.

To our knowledge, this is the first study to use the same facial perception task in adults with BPD that was used in pediatric BPD (Rich et al., 2008b). Interestingly, both studies found

impairments in sensitivity but not accuracy, suggesting that age and course of illness do not influence the nature of the deficits. Although this might also reflect the nature of the task, these findings are consistent with the results of a study by Bozikas and colleagues (2006) that found no correlation between face processing deficits and age of onset or duration of illness in adults with BPD. Moreover, because these deficits were found in euthymic and hypomanic/mixed children with BPD, it appears that the impairments may persist regardless of mood state (Rich et al., 2008b). This finding supports previous research showing a trait deficit in emotional processing for BPD (Addington and Addington, 1998; Bozikas et al., 2006; Summers et al., 2006). A separate prior comparison of children with BPD and depression/anxiety found differences in accuracy using another type of static face emotion identification task (Guyer et al., 2007). While that study found that children with BPD tended to misidentify facial emotions more often than depressed/anxious children, the current study did not find a difference in accuracy between adults with unipolar depression and BPD. Further work is needed to determine the extent to which different face processing tasks contribute to these somewhat discrepant results across the lifespan.

In the present task, some emotions appeared easier for participants to recognize than others, regardless of diagnosis. In particular, each group required a less intense happy expression before they first responded or correctly identified the face as compared to all other emotions. In addition, all groups obtained a high level of accuracy in identifying faces as happy. It is possible that the inclusion of only one positive emotion and four negative emotions caused a heightened contrast for happy faces, making them easier to identify. However, numerous studies have found that happy faces are recognized significantly faster and more accurately than other emotions (Calvo and Lundqvist, 2008; Ekman and Friesen, 1976; Leppanen et al., 2004; Palermo and Coltheart, 2004).

One limitation of this study is the lack of an assessment of participants' attention level when completing the task. Thus, it is difficult to establish the extent to which our results reflect limited attention instead of a deficit in emotion processing. Research on attentional deficits in medicated as well as unmedicated MDD report mixed results (Boone et al., 1995; Fischer et al., 2008; Majer et al., 2004). Previous studies exploring cognitive deficits in BPD discovered impaired attention in euthymic subjects as well as those with depression (Clark et al., 2005; Harmer et al., 2002; Holmes et al., 2008; Quraishi and Frangou, 2002). Future studies should include multiple measures to try to distinguish between attention deficits and impairments in emotional perception.

Another limitation is that the BPD group was medicated while the MDD group was medication-free. Although significant differences were not observed between these two groups, medication effects might account for the deficits observed in the BPD group. Moreover, only one subject in the BPD group was medication-free, so we could not test the difference between medicated versus unmedicated participants with BPD. One study found that participants with bipolar depression who were taking lithium or valproic acid made more errors when responding to happy words on an affective shift task as compared to unmedicated participants (Holmes et al., 2008). However, a study of individuals with pediatric BPD found no differences in performance between medicated and unmedicated subjects for the Multimorph Task (Rich et al., 2008b). In addition, imaging studies found no relationship between medication load and abnormal neural activity responses to emotional stimuli in bipolar individuals suggesting that the deficits are a function of the illness rather than medication (Hassel et al., 2008). Moreover, because a research staff member administered the task and operated the computer for the participants, we can rule out decreased motor responsivity as a reason for the findings. In the future, more studies should test the effects of medication on facial expression processing, although obtaining a medication-free BPD sample remains challenging.

Future research on the perception of emotions should explore the brain mechanisms involved in emotional processing deficits. Preliminary imaging studies have found distinct neuropathological patterns of emotional responses in BPD and MDD patients (Lee et al., in press). Specifically, abnormally elevated amygdala activity to sad and neutral faces has been found in BD but not MDD depression (Almeida et al., in press). Moreover, Lawrence and colleagues (2004) found that individuals with BPD displayed increased subcortical and ventral prefrontal cortical activation for all emotions as compared to unipolar subjects and controls, thus supporting the notion of pathophysiological differences between the two diagnoses. Moreover, this finding was not related to depression symptom severity, suggesting the impairments reflect a trait deficit. Increased activation in similar brain regions has also been found in pediatric BPD, along with impaired connectivity between the amygdala and temporal association cortical regions (Rich et al., 2008a; Rich et al., 2006). Thus, certain impairments in the brain mechanisms associated with facial processing appear to be characteristic of BPD.

This study supports some of the previous findings regarding the perception of facial emotion in bipolar depression, and contributes to the existing literature. An overall deficit in sensitivity to facial expressions appears to exist in bipolar depression, but not unipolar depression. These results help to further illustrate the similarities and differences between unipolar and bipolar depression, and could help distinguish unique and shared pathophysiology for these disorders.

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Figure 1.

Table 1

Comparison of demographic and course of illness characteristics for unipolar depression, bipolar depression, and control groups

	Controls		MDD		BPD		<i>F</i>	<i>df</i>	<i>p</i>
	<i>Mean (SD)</i>		<i>Mean (SD)</i>		<i>Mean (SD)</i>				
Age	45.3 (13.9)		45.0 (12.8)		46.8 (11.8)		0.13	2, 76	.88
Age of Onset	NA		19.1 (10.2)		18.5 (9.4)		0.04	1, 52	.83
IQ	118.3 (11.0)		120.5 (11.1)		118.6 (9.3)		0.35	2, 73	.71
MADRS	1.5 (2.5)		32.2 (4.9)		31.1 (6.6)		302.46	2, 65	<.001
YMRS	NA		4.2 (2.4)		5.0 (2.6)		1.09	1, 41	.30
	<i>N (%)</i>		<i>N (%)</i>		<i>N (%)</i>		χ^2	<i>df</i>	<i>p</i>
Sex (Female)	12 (50)		15 (44)		13 (62)		1.65	2	.44
Bipolar Subtype (Type I)	NA		NA		9 (45)		-	-	-

BPD: Bipolar Disorder; MADRS: Montgomery-Asberg Depression Rating Scale; MDD: Major Depressive Disorder; YMRS: Young Mania Rating Scale

Table 2

Linear mixed model comparing morph level between MDD, BPD, and control groups

First Response	Diagnosis (D)	F, df, p	Post Hoc
Emotion (E)*		3.59, 2, 76, .03	Controls > BPD
Trial (T)		139.92, 5, 2660, <.001	H > D, Su, Sa, A, F, D > F, Sa
D × E		6.48, 5, 2660, <.001	1, 3–6 > 2
D × T		1.01, 10, 1995, .43	
E × T		0.59, 10, 1995, .82	
D × E × T		1.13, 25, 1995, .30	
		0.92, 50, 1995, .63	
Correct Response	Diagnosis (D)	4.31, 2, 75, .02	Controls > BPD
Emotion (E)*		165.93, 5, 2269, <.001	H > Su, Sa, A, D, F, Su, Sa, A > F
Trial (T)		3.77, 5, 2268, .002	5, 6 > 2
D × E		0.75, 10, 1692, .68	
D × T		1.53, 10, 1692, .12	
E × T		1.16, 25, 1691, .26	
D × E × T		0.83, 50, 1691, .80	
Correct Response (Zeros)	Diagnosis (D)	3.98, 2, 76, .02	Controls > BPD
Emotion (E)*		201.42, 5, 2660, <.001	H > Su, Sa, A > D, F
Trial (T)		4.95, 5, 2660, <.001	1, 4, 5, 6 > 2
D × E		1.11, 10, 1995, .35	
D × T		1.36, 10, 1995, .19	
E × T		1.27, 25, 1995, .17	
D × E × T		0.74, 50, 1995, .91	
% Correct	Diagnosis (D)	1.80, 2, 76, .17	
Emotion (E)*		20.00, 5, 380, <.001	H > Su, Sa, F, A > D
D × E		1.53, 10, 380, .13	

* A = Angry, D = Disgusted, F = Fearful, H = Happy, Sa = Sad, Su = Surprised

BPD: Bipolar Disorder; MDD: Major Depressive Disorder

Table 3

Cohen's d by Outcome and Emotion

	<u>BPD vs. Controls</u>	<u>BPD vs. MDD</u>	<u>MDD vs. Controls</u>
First Response			
• Overall	-.61	-.41	-.26
• Emotion			
• Disgust	-.39	-.30	-.12
• Surprise	-.36	-.33	-.05
• Anger	-.35	-.35	-.03
• Fear	-.32	-.13	-.23
• Sad	-.40	-.21	-.23
• Happy	-.50	-.22	-.33
Correct Response			
• Overall	-.68	-.42	-.32
• Emotion			
• Disgust	-.36	-.23	-.15
• Surprise	-.37	-.31	-.10
• Anger	-.36	-.25	-.13
• Fear	-.29	-.12	-.18
• Sad	-.19	-.14	-.07
• Happy	-.36	-.11	-.29
Correct Response(Zeros)			
• Overall	-.65	-.37	-.35
• Emotion			
• Disgust	-.30	-.16	-.17
• Surprise	-.34	-.32	-.04
• Anger	-.34	-.20	-.18
• Fear	-.16	-.02	-.16
• Sad	-.26	minus;.16	-.13
• Happy	-.36	-.13	-.26
% Correct			
• Overall	-.03	.34	-.39
• Emotion			
• Disgust	.03	.16	-.14
• Surprise	-.03	-.05	.01
• Anger	-.04	.09	-.13
• Fear	.20	.29	-.08
• Sad	-.16	-.05	-.13
• Happy	-.03	-.03	.00

Negative value means the first group listed had a lower score. Cohen's $d = 2t/\sqrt{df}$.

BPD: Bipolar Disorder; MDD: Major Depressive Disorder