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Perceptual asymmetry and youths' responses to stress: Understanding vulnerability to depression

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Abstract

This research examined the hypothesis that reduced posterior right hemisphere activity interferes with the regulation of emotions and behavior in response to stress, creating vulnerability to depression. Consistent with a diathesis-stress model, we predicted that youth with a reduced posterior right hemisphere bias in emotional processing would engage in less adaptive responses to stress, which would be associated with depressive symptoms in those who reported the recent experience of high, but not low, levels of stress. Participants were 510 4th through 8th graders who completed the Chimeric Faces Task and measures of responses to stress and depressive symptoms. Results supported the idea that responses to stress account for the association between reduced posterior right hemisphere activity and depressive symptoms in youth who report high, but not low, levels of stress. This study provides insight into one process through which reduced posterior right hemisphere activity may confer vulnerability to depressive symptoms, and implicates responses to stress as a target for intervention.

Psychobiological models of depression consider the role of regional brain activity in emotion processing and affective states (Davidson, 1988; Heller & Nitschke, 1997). For example, research suggests that the right posterior hemisphere is specialized for the processing of emotional information in nondepressed individuals, whereas sad affect and depression are linked to a reduced right hemisphere bias, hypothesized to reflect a suppression of activity in this region (Heller, Etienne, & Miller, 1995; Heller & Nitschke, 1997). Although this research provides some insight into atypical patterns of regional brain activity associated with depression, two critical issues have not been addressed, particularly in youth. First, research primarily examines associations between hemispheric activation and depression without a consideration of context. Second, little is known about the processes linking characteristic patterns of hemispheric activation and depression. The goal of the present study was to test the hypothesis that youth who demonstrate reduced posterior right hemisphere activity, as reflected in perceptual asymmetry in the processing of emotion, would respond to stress in ways that are linked to depression. Consistent with diathesis-stress models of psychopathology (Monroe & Simons, 1991), we expected that this process would occur in youth who reported the experience of high, but not low, levels of stress during the preceding months.

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Posterior Right Hemisphere Activity and Depression

Research demonstrates that depression is associated with a suppression of right parietotemporal hemisphere function in adults (for reviews, see Heller, 1990; Heller & Nitschke, 1997) but this association has gone unexamined in youth. This characteristic pattern of hemispheric asymmetry in depressed adults is reflected in less effective performance or reduced perceptual asymmetry on tasks specialized to the posterior right hemisphere (Banich, Stolar, Heller, & Goldman, 1990; Bruder et al., 1995; Kucharska-Pietura & David, 2003), and decreased brain activity over the posterior right hemisphere as detected by electrophysiological (EEG) recordings (Bruder et al., 1997; Deldin, Keller, Gergen, & Miller, 2000; Henriques & Davidson, 1997; Kayser, Bruder, Tenke, Stewart, & Quitkin, 2000). We expected, therefore, that a reduced posterior right hemisphere bias would be associated with depressive symptoms. Importantly, we expected that this bias would serve as a diathesis for depression specifically in the face of stress. Research using EEG recordings shows that individuals at high risk for depression (the offspring of depressed parents) show relatively less posterior right hemisphere activity than those at low risk, independent of their history of depression (Bruder et al., 2005), suggesting that this atypical pattern might serve as a vulnerability marker for depression. In the present study, we tested this possibility by examining whether the link between posterior right hemisphere activity and depressive symptoms was moderated by youths' exposure to recent stress.

Posterior Right Hemisphere Activity and Responses to Stress

Why might reduced posterior right hemisphere activity create a vulnerability to depression in youth who experience high levels of stress? Using behavioral methods (e.g., performance on emotion-related lexical tasks and visual emotion perception tasks) research indicates that the right hemisphere is involved in the accurate identification and evaluation of emotion (Borod, Andelman, Obler, Tweedy, & Welkowitz, 1992; Borod, Koff, Lorch, & Nicholas, 1986). Difficulties with emotion identification and processing might interfere with youths' ability to respond adaptively to stress. Contemporary models of responses to stress (Compas, Connor-Smith, Saltzman, Thomsen, & Wadsworth, 2001; Rudolph, Dennig, & Weisz, 1995) distinguish between (a) engagement with stressors versus disengagement from stressors, and (b) effortful responses to stress (i.e., coping responses) versus involuntary, dysregulated responses to stress (e.g., heightened arousal). Individuals who are able to clearly identify and process their emotional reactions to stress might engage in effortful planning and implementation of effective coping responses (e.g., Gohm & Clore, 2000). In contrast, individuals who are unable to clearly identify and process their emotions might become overwhelmed by stress and react in an unsystematic and dysregulated manner. Consistent with this idea, Compton and colleagues (2003) found that reduced posterior right hemisphere activity was associated with maladaptive response styles, specifically rumination, in women. Thus, we predicted that reduced posterior right hemisphere activity would be associated with less effortful and more involuntary responses to stress, particularly in youth who reported the experience of high, but not low, levels of stress in the preceding months.

Responses to Stress and Depression

Maladaptive responses to stress might create a vulnerability to depression due to heightened experiences of negative affect and failure to successfully resolve or adapt to stressful situations. Indeed, research indicates that voluntary engagement responses are associated with lower levels of emotional distress, whereas involuntary engagement responses are associated with higher levels of emotional distress (Connor-Smith, Compas, Wadsworth, Thomsen, & Saltzman, 2000; Langrock, Compas, Keller, Merchant, & Copeland, 2002).

Overview of the Present Study

Despite the growing body of theory and research implicating atypical hemispheric activation in depression, little is known about why or under what conditions these patterns of regional brain activity create a vulnerability to depression. The goal of this study was to examine the hypothesis that maladaptive responses to stress (i.e., lower levels of voluntary responses and high levels of involuntary, dysregulated responses) account for the association between reduced posterior right hemisphere activity and depressive symptoms in youth who experience high, but not low, levels of stress. Specifically, we focused on youths' recent exposure and responses to stress in the peer group. Peer relationships serve as a salient socialization context for youth (Rose & Rudolph, 2006). Moreover, stress within interpersonal relationships plays a particularly strong role in the development of depressive symptoms (Rudolph & Hammen, 1999; for reviews, see Hankin & Abramson, 2001; Rudolph, 2002). Thus, we expected that stressful experiences in the peer group might be especially likely to moderate the association between reduced posterior right hemisphere activity and depressive symptoms.

Posterior right hemisphere activity was measured with the Chimeric Faces Task (CFT; Levy, Heller, Banich, & Burton, 1983a), a free-vision behavioral task of face processing. The CFT elicits a reliable left hemispatial (right hemisphere) bias, which can be expressed as a perceptual asymmetry score. Perceptual asymmetry scores are thought to index hemispheric specialization, as right hemisphere biases consistently are found for the processing of visuospatial and emotion tasks, whereas left hemisphere biases consistently are found for the processing of linguistic tasks (see Levy et al., 1983a). These biases have been attributed to activity in posterior regions of the brain. Lesion studies indicate that damage to the posterior right hemisphere interferes with face recognition (e.g., Newcombe, De Haan, Ross, & Young, 1989), and neuroimaging studies suggest that face processing is localized primarily in right inferior temporal cortex (e.g., Sams, Hietanen, Hari, Ilmoniemi, & Lounasmaa, 1997; Sergent, Ohta, & MacDonald, 1992). Also, tachistoscopic tasks typically yield perceptual asymmetry scores that indicate left visual field, or right hemisphere, superiority for face processing (Hilliard, 1973; Klein, Moscovitch, & Vigna, 1976), and these perceptual asymmetry scores share a large portion of the variance with scores on the CFT (Kim, Levine, & Kertesz, 1990). Moreover, reduced right hemisphere bias on the CFT is correlated with increased left hemisphere bias on a tachistoscopic task of linguistic information processing (Levy, Heller, Banich, & Burton, 1983b). This left hemisphere bias is, in turn, correlated with increased EEG activity in the posterior left hemisphere (Green, Morris, Epstein, West, & Engler, 1992), suggesting that hemispheric asymmetries on tachistoscopic tasks reflect increased regional brain activity. Taken together, these findings suggest that the CFT is engaging posterior regions of the brain specialized for face processing, and that one component of perceptual asymmetry scores on this task reflects variations in the degree of characteristic right versus left posterior hemisphere activity.

Method

Participants

Participants were 510 fourth through eighth graders (243 girls, 267 boys), ranging in age from 9 to 15 years (M = 11.67, SD = 1.50). Youth were primarily White (98.8% White, 0.6% African-American, and 0.6% Latino/Hispanic), and were diverse in terms of socioeconomic status (25% received a federally subsidized lunch). Of the original 584 students attending a grade school (grades 4 and 5) and a junior high school (grades 6, 7, and 8) in a rural town in the Midwest, 560 (96%) participated in the study (1.5% no consent; 2.5% substantial missing data). An additional 50 students (8.6% of the original sample) were excluded because time constraints during the administration process prevented them from completing the Chimeric Faces Task, yielding the present sample of 510 youth.

Procedures

A series of questionnaires was administered in a classroom setting to youth with parental consent. Questions were read aloud by a clinical psychology faculty member or graduate student while children provided written responses.

Measures

Responses to Stress Questionnaire—Peer Stressor Version (RSQ; Connor-Smith et al., 2000)—The RSQ is designed to measure youths' effortful (i.e., voluntary, volitional) and involuntary (i.e., temperamental, conditioned, dysregulated) responses to stress. First, youth document how many of nine specific peer stressors (e.g., being teased or hassled by other kids, having problems with a friend) had occurred to them since the beginning of the school year. Next, youth rate on a 4-point scale (1 = *Not at all* to 4 = *A lot*) how much they engaged in 57 responses to the stressors. The measure is composed of 19 subscales. Confirmatory factor analysis (Connor-Smith et al., 2000) yielded 5 factors that showed strong internal consistency in the present sample: Primary Control Engagement (efforts to influence stressful events and to regulate one's emotions; e.g., emotional expression, problem solving; α = .80), Secondary Control Engagement (efforts to adapt to stressful events; e.g., cognitive restructuring, acceptance; α = .80), Effortful Disengagement (e.g., denial, avoidance, wishful thinking; α = .75), Involuntary Engagement (e.g., emotional arousal, rumination, impulsive action; α = .91), and Involuntary Disengagement (e.g., emotional numbing, inaction, cognitive interference; α = .87). Convergent validity and retest reliability for the five factors have been established (Connor-Smith et al., 2000). Following Connor-Smith et al. (2000), to correct for base-rate differences in the endorsement of responses to stress (Compas et al., 2001), proportion scores were calculated as the total score for each factor divided by the total score on the RSQ. Higher scores on these subscales reflect higher levels of each type of response to stress.

Chimeric Faces Task (CFT; Levy et al., 1983a)—The CFT is a free-vision task in which youth choose which of two chimeric faces (one with a smile on the right side and the other with a smile on the left side), displayed in a vertical arrangement, looks happier. An "undecided" response is provided if no answer can be given. A perceptual asymmetry score is calculated based on the youths' preference for the smile in the left visuospatial field (indicating right hemisphere activity; scored as −1) versus the right visuospatial field (indicating left hemisphere activity; scored as +1). The responses are tallied and divided by the total number of items to provide a mean perceptual asymmetry score, which indicates the relative level of posterior right versus left hemisphere activity. *Higher* scores on the measure reflect a *reduced* posterior right hemisphere bias; a score of zero indicates no perceptual bias. The CFT yields stable laterality scores across time and a consistent bias (Levy et al., 1983a). In addition, the 36-item version of the CFT has high split-half reliability (Wirsen, Klinteberg, Levander, & Schalling, 1990). The present study used an 18-item version of the CFT (Compton et al., 2003; α = .76).

Children's Depression Inventory (CDI; Kovacs, 1980/81)—The CDI, one of the most widely used self-report measures of depressive symptoms in youth, includes 27 items that yield a total score ranging from 0 to 54. For each item, youth endorse one of three statements that describe no, mild, or severe depressive symptoms. Adequate internal consistency and test-retest reliability have been established (Kovacs, 1980/81; Smucker, Craighead, Craighead, & Green, 1986). High internal consistency (α = .92) was found in the present sample.

Results

Overview of Analyses

First, correlations were computed to examine the general pattern of associations among perceptual asymmetry scores, responses to stress, and depressive symptoms in youth who reported the experience of high versus low levels of stress. Second, structural equation modeling (SEM) analyses were conducted with Amos Version 4.0 (Arbuckle, 1999) to test whether responses to stress mediated the association between a reduced right hemisphere bias and depressive symptoms, and whether mediation was stronger in youth who experienced high versus low levels of stress. Youth who did not endorse any peer stressors (n = 99) were excluded from analyses because they were thought to be hypothesizing how they *might* respond instead of how they *had* responded to stress. Low stress (1–3 stressors, n = 304) and high stress (4–9 stressors, n = 107) groups were created based on the mean number of peer stressors reported. The low stress group (165 boys, 139 girls) ranged in age from 9 to 15 years (M = 11.70, SD = 1.49). CDI scores ranged from 0 to 42 (M = 7.79, SD = 7.11). CFT scores ranged from −1 to 1 (M = −0.28, SD = 0.38). The high stress group (48 boys, 59 girls) ranged in age from 9 to 15 years (M = 11.53, SD = 1.57). CDI scores ranged from 0 to 50 (M = 17.07, SD = 11.34). CFT scores ranged from −1 to 0.67 (M = −0.34, SD = 0.39). As would be expected, the high stress group was significantly more depressed than the low stress group, $t(404) = 9.75$, $p < .001$. Thirty-eight percent of youth in the high stress group scored in the severely depressed range (above 18) on the CDI whereas 9% of the low stress group scored in this range. The two groups did not significantly differ in sex, $\chi^2(1) = 2.81$, *ns*, age, $t(409) = .97$, *ns*, or scores on the CFT, $t(398) = 1.39$, *ns*.

Correlation Analyses

Table 1 displays intercorrelations among perceptual asymmetry scores, responses to stress, and depressive symptoms. As expected, a reduced right hemisphere bias was significantly associated with less effortful engagement coping in the high stress, $r(99) = -.21$, $p < .05$, but not the low stress, $r(294) = -.05$, *ns*, group. When the primary and secondary control coping dimensions were analyzed separately, a reduced right hemisphere bias was significantly associated with less secondary control coping but not with primary control coping in the high stress group (see Table 1). In addition, as predicted, a reduced right hemisphere bias was significantly associated with more involuntary disengagement and with higher levels of depressive symptoms in the high stress, but not the low stress, group. As predicted, therefore, a reduced right hemisphere bias was associated with less adaptive responses to stress and depressive symptoms in youth who reported the experience of high, but not low, levels of stress.

Structural Equation Modeling Analyses

A multi-group comparison analysis was conducted using structural equation modeling to test whether maladaptive responses to stress mediated the association between a reduced right hemisphere bias and depressive symptoms, and whether this mediation varied across stress groups. A direct comparison of constrained (paths were set to be equal across stress groups) and unconstrained (paths were allowed to vary across stress groups) models allowed us to examine whether the pattern of mediation differed significantly under conditions of high versus low stress. Based on the pattern of correlations, responses to stress were represented by a latent variable composed of secondary control engagement coping and involuntary disengagement. Perceptual asymmetry scores and depressive symptoms were represented by observed variables. Paths were included from perceptual asymmetry scores to responses to stress, and from responses to stress to depressive symptoms (see Figure 1). In addition, the direct path from perceptual asymmetry scores to depressive symptoms was included.

Consistent with the expectation that the proposed model would characterize youth who experienced high but not low levels of stress, a chi-square difference test, $\Delta\chi^2(3) = 12.49$, $p < .01$, revealed that the unconstrained model, $\chi^2(2) = 1.97$, *ns*, $\chi^2/df = .98$, RMSEA = .000, fit significantly better than the constrained model, $\chi^2(5) = 14.46$, $p < .05$, $\chi^2/df = 2.89$, RMSEA = .068. Figure 1 displays standardized path coefficients for the unconstrained model in the high and low stress groups. Examination of the squared multiple correlations (i.e., proportion of variance in depressive symptoms explained by perceptual asymmetry scores and responses to stress) indicated that the model predicted 44% of the variance in depressive symptoms in the high stress group, and 33% in the low stress group (a large effect size for the former and a medium-to-large effect size for the latter; Cohen, 1992).

Following recommended guidelines (Baron & Kenny, 1986; Kenny, Kashy, & Bolger, 1998; MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002; Shrout & Bolger, 2002), several indicators were examined to evaluate mediation in the high stress group (because the total effect of perceptual asymmetry scores on depressive symptoms, as indicated by the correlations, and the path from perceptual asymmetry scores to responses to stress were close to zero in the low stress group, mediation was not examined). First, we examined the size and significance of the indirect effect (Sobel, 1982; 1986). As anticipated, a reduced right hemisphere bias was significantly associated with maladaptive responses to stress, which were significantly associated with depressive symptoms (see Figure 1; indirect effect = .15, Z = 2.17, $p < .05$). Second, the significant total effect of a reduced right hemisphere bias on depressive symptoms (β= .27, $p < .01$) was reduced to nonsignificance once responses to stress were included in the model. Third, following Shrout and Bolger (2002), to quantify the strength of mediation we calculated an effect proportion (indirect effect/total effect). The effect proportion indicated that 56% of the total effect of perceptual asymmetry scores on depressive symptoms was accounted for by responses to stress. Together, these indicators suggest that responses to stress mediated the association between a reduced right hemisphere bias and depressive symptoms.

Discussion

Although research consistently links reduced posterior right hemisphere activity with depression in adults (Banich et al., 1990; Bruder et al., 1995; Heller et al., 1995), the process underlying this association remains largely unexamined. The results of the present study support the hypothesis that youths' responses to peer stress partially account for the association between reduced posterior right hemisphere activity and depressive symptoms, although the amount of variance in depressive symptoms accounted for by reduced posterior right hemisphere activity was small. This research represents an important first step in identifying one process linking a reduced posterior right hemisphere bias and depressive symptoms.

Posterior right hemisphere activity has been implicated in the identification and interpretation of emotional information (Heller, 1990; Heller & Levy, 1981). Individuals who are unable to accurately identify and process emotions in themselves or others might be less likely to display situationally appropriate emotional displays and behaviors and, ultimately, might respond less adaptively to stress. Indeed, as expected, results from the present study revealed that a reduced right hemisphere bias was significantly associated with lower levels of effortful engagement coping (particularly secondary control coping) and higher levels of dysregulated, involuntary disengagement responses to stress. Consistent with a diathesis-stress model, however, this bias did not serve as a vulnerability factor for emotional or behavioral dysregulation in youth experiencing relatively low levels of stress.

Involuntary disengagement from stressors, such as experiencing a numbing of emotions or an inability to focus on problems, might reflect temperamentally based or conditioned reactions that interfere with planful efforts to cope with stressful situations. Involuntarily disengaging in response to peer stress might preclude adaptive self-regulation and impair active efforts to resolve stressful situations with peers. Over time, a tendency to involuntarily disengage from stressful interpersonal encounters might cause youth to develop a lower sense of self-efficacy or hopelessness about their ability to respond to challenging interpersonal situations. Moreover, a failure to engage in secondary control coping, such as reinterpreting peer difficulties in a less negative light, might heighten youths' immediate negative emotional reactions to stress. A diminished sense of self-efficacy, hopelessness, and negative affect might, in turn, increase youths' risk for depression (Abramson, Metalsky, & Alloy, 1989; Hankin & Abramson, 2001).

Conversely, youth who engage in secondary control coping responses might deal more effectively with stressful situations and associated emotions. For instance, they might reframe negative experiences with peers or accept challenging situations without making negative inferences about themselves, allowing them to respond more adaptively. Particularly when experiencing high levels of stress, the tendency to engage in effortful coping might allow youth to gain confidence in their ability to manage interpersonal stress and, consequently, to feel a greater sense of self-efficacy and self-worth. Ultimately, youth who adopt this approach also might develop more adaptive peer relationships that protect them from depressive symptoms.

Contrary to hypotheses, reduced posterior right hemisphere activity was not associated with involuntary engagement responses, such as rumination, intrusive thoughts, and physiological and emotional arousal. These results were not consistent with prior findings indicating an association between a reduced posterior right hemisphere bias and rumination (Compton et al., 2003). However, this discrepancy might be due to methodological differences, as Compton and colleagues assessed how often individuals engage in rumination in response to *depressive symptoms* rather than in response to stress.

Also contrary to hypotheses, we did not find a link between reduced posterior right hemisphere activity and effortful disengagement responses. Although we hypothesized that a reduced posterior right hemisphere bias would be associated with less effortful responses to stress, it is possible that deficits in emotion identification and evaluation foster lower levels of some forms of effortful disengagement and higher levels of others, resulting in a null association for the overall factor. To further investigate this possibility, we conducted exploratory analyses examining the correlations between perceptual asymmetry scores and subscales within the effortful disengagement factor. These analyses revealed that a reduced posterior right hemisphere bias was significantly *positively* associated with denial but marginally *negatively* associated with avoidance in the high, but not low, stress group. Youth who display deficits in emotion identification and evaluation might not have the emotional resources to engage in purposeful strategies that allow them to actively avoid stressful situations, but instead might become so overwhelmed that they attempt to alleviate their emotional discomfort by denying the existence of stressors. This denial might even lead to involuntary disengagement from stress. The idea that different types of effortful disengagement responses are not uniformly associated with emotional well-being is consistent with the lack of association between these responses and depressive symptoms in the present research, as well as with theory and research suggesting that the adaptiveness of effortful disengagement responses depends on the nature and context of stressors (Forsythe & Compas, 1987; Rudolph et al., 1995; Weisz, McCabe, & Dennig, 1994).

Overall, the results of the present study are consistent with the hypothesis that a reduced posterior right hemisphere bias interferes with youths' ability to respond adaptively to stress, creating a vulnerability to depressive symptoms. Consistent with a diathesis-stress model, this process occurred only in youth who had recently experienced high levels of stress. However, due to the concurrent nature of the data, alternative explanations also are feasible. For example, depressive symptoms might interfere with effective regulation of emotion and behavior in response to stress, and either symptoms or maladaptive responses to stress might influence posterior right hemisphere functioning.

Data from several other lines of research shed light on the possible direction of effects. Although some assessments of perceptual asymmetry vary as a function of affective state (Banich, Elledge, & Stolar, 1992), perceptual asymmetry measured with the CFT in adults is stable across days (Berenbaum & Williams, 1994), weeks (Bibawi, Cherry, & Hellige, 1995), and hormonal cycles (Compton & Levine, 1997). Moreover, one longitudinal study in adults revealed that a reduced right hemisphere bias on the CFT predicted future depression (i.e., lower levels of positive affect) but depression did not predict future performance on the CFT (Voelz et al., 2001). Less is known about the development and stability of perceptual asymmetry in youth. However, a right posterior hemisphere preference for processing emotional stimuli has been demonstrated as early as six or seven years of age; the magnitude of this asymmetry increases in ten year olds and then stabilizes (Chiang, Ballantyne, & Trauner, 2000). Furthermore, research examining the development of perceptual asymmetry in both posterior and anterior regions suggests that patterns of asymmetry become more similar to those of adults as children mature from early to middle childhood (Pollak & Wismer Fries, 2001).

Collectively, these findings suggest that perceptual asymmetry in emotion processing becomes stable by middle childhood and might not be influenced by affective experiences such as depression. Indeed, research reveals that individuals at high risk for depression show relatively less posterior right hemisphere activity than those at low risk, independent of their history of depression (Bruder et al., 2005). This evidence supports the idea that reduced posterior right hemisphere activity represents a stable predisposition that might serve as a vulnerability marker for depression. However, a twin study revealed that this predisposition is influenced by non-shared environmental experiences rather than by genetics or shared environmental factors (Valera, Heller, & Berenbaum, 1999). It is possible, therefore, that individual differences in perceptual asymmetry in older children and adults are a product of environmental experiences that influence hemispheric development during early childhood. In the present study, perceptual asymmetry scores did not differ significantly across the high and low stress groups, suggesting that *recent* stressful peer experiences were not associated with this predisposition. However, prospective longitudinal research is needed to examine the role of early experience in the development of perceptual asymmetry.

Future investigations also need to examine how activation in the right posterior hemisphere interacts with other brain regions to influence emotional processing, responses to stress, and affective experience. This is of particular importance because, although posterior right hemisphere functioning largely drives performance on the CFT, performance on this task is ambiguous in that it does not directly or specifically index posterior right hemisphere activity and likely reflects interactions between posterior circuitry and other regions. We proposed that decreased posterior right hemisphere activity creates difficulties in recognizing and processing emotions, which may compromise strategies for regulating emotions and behavior. However, anterior regions of the right and left hemispheres also have been implicated in depression (Henriques & Davidson, 1991), and these regions are involved directly in the regulation of emotion and behavior (Davidson, 1998). Deficits in emotional awareness linked to posterior regions might interact with deficits in regulatory strategies linked to anterior regions to create a vulnerability to depression. Thus, developing a comprehensive psychobiological model of depression will require understanding the joint contribution of dysfunction across different brain regions to the development and maintenance of depressive disorders.

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References

Abramson LY, Metalsky GI, Alloy LB. Hopelessness depression: A theory-based subtype of depression. Psychological Review. 1989; 96:358–372.

Arbuckle, JL. AMOS 2 [Computer Software]. Chicago: Small Waters Corp; 1999.

Banich MT, Elledge VC, Stolar N. Variations in lateralized processing among right-handers: Effects on patterns of cognitive performance. Cortex. 1992; 28:273–288. [PubMed: 1499312]

Banich MT, Stolar N, Heller W, Goldman R. A deficit in right hemisphere performance after induction of a depressed mood. Neuropsychiatry, Neuropsychology and Behavioral Neurology. 1990; 5:20–27.

Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. Journal of Personality and Social Psychology. 1986; 51:1173–1182. [PubMed: 3806354]

Berenbaum H, Williams M. Extraversion, hemispatial bias, and eyeblink rates. Personality and Individual Differences. 1994; 17:849–852.

Biwabi D, Cherry B, Hellige JB. Fluctuations of perceptual asymmetry across time in women and men: Effects related to the menstrual cycle. Neuropsychologia. 1995; 33:131–138. [PubMed: 7731537]

Borod JC, Andelman F, Obler LK, Tweedy JR, Welkowitz J. Right hemisphere specialization for the identification of emotional words and sentences: Evidence from stroke patients. Neuropsychologia. 1992; 30:827–844. [PubMed: 1407497]

Borod JC, Koff E, Lorch MP, Nicholas M. The expression and perception of facial emotion in brain-damaged patients. Neuropsychologia. 1986; 24:169–180. [PubMed: 3714022]

Bruder GE, Fong R, Tenke CE, Leite P, Towey JP, Stewart JE, et al. Regional brain asymmetries in major depression with or without an anxiety disorder: A quantitative electroencephalographic study. Biological Psychiatry. 1997; 41:939–948. [PubMed: 9110099]

Bruder GE, Tenke CE, Stewart JW, Towey JP, Leite P, Voglmaier M, et al. Brain event related potentials to complex tones in depressed patients: Relations to perceptual asymmetry and clinical features. Psychophysiology. 1995; 32:373–381. [PubMed: 7652114]

Bruder GE, Tenke CE, Warner V, Nomura Y, Grillon C, Hille J, et al. Electroencephalographic measures of regional hemispheric activity in offspring at risk for depressive disorders. Biological Psychiatry. 2005; 57:328–335. [PubMed: 15705347]

Chiang CH, Ballantyne AO, Trauner DA. Development of perceptual asymmetry for free viewing of chimeric stimuli. Brain and Cognition. 2000; 44:415–424. [PubMed: 11104534]

Cohen J. A power primer. Psychological Bulletin. 1992; 112:155–159. [PubMed: 19565683]

Compas BE, Connor-Smith JK, Saltzman H, Thomsen AH, Wadsworth ME. Coping with stress during childhood and adolescence: Problems, progress, and potential in theory and research. Psychological Bulletin. 2001; 127:87–127. [PubMed: 11271757]

Compton RJ, Fisher LR, Koenig LM, McKeown R, Munoz K. Relationship between coping styles and perceptual asymmetry. Journal of Personality and Social Psychology. 2003; 84:1069–1078. [PubMed: 12757149]

Compton RJ, Levine SC. Menstrual cycle phase and mood effects on perceptual asymmetry. Brain and Cognition. 1997; 35:168–183. [PubMed: 9356160]

Connor-Smith JK, Compas BE, Wadsworth ME, Thomsen AH, Saltzman H. Responses to stress in adolescence: Measurement of coping and involuntary stress responses. Journal of Consulting and Clinical Psychology. 2000; 68:976–992. [PubMed: 11142550]

Davidson, RJ. Affect, cognition, and hemispheric specialization. In: Izard, CE.; Kagan, J.; Zajonc, RB., editors. Emotions, cognition, and behavior. Cambridge, UK: Cambridge University Press; 1988. p. 320-365.

Davidson RJ. Affective style and affective disorders: Perspectives from affective neuroscience. Cognition and Emotion. 1998; 12:307–330.

Deldin PJ, Keller J, Gergen JA, Miller GA. Right-posterior face processing anomaly in depression. Journal of Abnormal Psychology. 2000; 109:116–121. [PubMed: 10740942]

Forsythe CJ, Compas BE. Interactions of coping and perceptions of control: Testing the goodness of fit hypothesis. Cognitive Therapy and Research. 1987; 11:473–485.

Gohm CL, Clore GL. Four latent traits of emotional experience and their involvement in well-being, coping, and attributional style. Cognition and Emotion. 2000; 16:495–518.

Green J, Morris RD, Epstein CM, West PD, Engler HF. Assessment of the relationship of cerebral hemisphere arousal asymmetry to perceptual asymmetry. Brain and Cognition. 1992; 20:264–279. [PubMed: 1449757]

Hankin BL, Abramson LY. Development of gender differences in depression: An elaborated cognitive vulnerability-transactional stress theory. Psychological Bulletin. 2001; 127:773–796. [PubMed: 11726071]

Heller, W. The neuropsychology of emotion: Developmental patterns and implications for psychopathology. In: Stein, N.; Leventhal, BL.; Trabasso, T., editors. Psychological and biological approaches to emotion. Hilsdale, NJ: Erlbaum; 1990. p. 167-211.

Heller W, Etienne MA, Miller GA. Patterns of perceptual asymmetry in depression and anxiety: Implications for neuropsychological models of emotion and psychopathology. Journal of Abnormal Psychology. 1995; 104:327–333. [PubMed: 7790634]

Heller W, Levy J. Perception and expression of emotion in right-handers and left-handers. Neuropsychologia. 1981; 19:263–272. [PubMed: 7254505]

Heller W, Nitschke JB. Regional brain activity in emotion: A framework for understanding cognition in depression. Cognition & Emotion. 1997; 11:637–661.

Henriques JB, Davidson RJ. Left frontal hypoactivation in depression. Journal of Abnormal Psychology. 1991; 100:535–545. [PubMed: 1757667]

Henriques JB, Davidson RJ. Brain electrical asymmetries during cognitive task performance in depressed and nondepressed subjects. Biological Psychiatry. 1997; 42:1039–1050. [PubMed: 9386856]

Hilliard RD. Hemispheric laterality effects on a facial recognition task in normal subjects. Cortex. 1973; 9:246–258. [PubMed: 4777738]

Kayser J, Bruder GE, Tenke CE, Stewart JW, Quitkin FM. Event-related potentials (ERPs) to hemifield presentation of emotional stimuli: Differences between depressed patients and healthy adults in P3 amplitude and asymmetry. International Journal of Psychophysiology. 2000; 36:211–236. [PubMed: 10754195]

Kenny, DA.; Kashy, DA.; Bolger, N. Data analysis in social psychology. In: Gilbert, DT.; Fiske, ST.; Lindzey, G., editors. Handbook of Social Psychology. 4. Vol. 1. New York: Oxford University Press; 1998. p. 233-265.

Kim H, Levine SC, Kertesz S. Are variations among subjects in lateral asymmetry real individual differences or random error in measurement? Brain and Cognition. 1990; 14:220–242. [PubMed: 2285515]

Klein D, Moscovitch M, Vigna C. Attentional mechanisms and perceptual asymmetries in tachistoscopic recognition of words and faces. Neuropsychology. 1976; 14:55–66.

Kovacs M. Rating scales to assess depression in school-aged children. Acta Paedopsychiatry. 1980/81; 46:305–315.

Kucharska-Pietura K, David AS. The perception of emotional chimeric faces inpatients with depression, mania, and unilateral brain damage. Psychological Medicine. 2003; 33:739–745. [PubMed: 12785476]

Langrock AM, Compas BE, Keller G, Merchant MJ, Copeland M. Coping with the stress of parental depression: Parents' reports of children's coping, emotional, and behavioral problems. Journal of Clinical Child & Adolescent Psychology. 2002; 31:312–324. [PubMed: 12149969]

Levy J, Heller W, Banich MT, Burton LA. Asymmetries of perception in free viewing of chimeric faces. Brain and Cognition. 1983a; 2:409–419.

Levy J, Heller W, Banich MT, Burton LA. Are variations among right-handed individuals in perceptual asymmetry caused by characteristic arousal differences between hemispheres? Journal of Experimental Psychology: Human Perception and Performance. 1983b; 9:329–359. [PubMed: 6223975]

MacKinnon DP, Lockwood CM, Hoffman JM, West SG, Sheets V. A comparison of methods to test mediation and other intervening variable effects. Psychological Methods. 2002; 7:83–104. [PubMed: 11928892]

Monroe SM, Simons AD. Diathesis-stress theories in the context of life stress research: Implications for depressive disorders. Psychological Bulletin. 1991; 110:406–425. [PubMed: 1758917]

Newcombe F, De Haan EHF, Ross J, Young AW. Face processing, laterality, and contrast sensitivity. Neuropsychologia. 1989; 27:523–538. [PubMed: 2733825]

Pollak SD, Wismer Fries AB. Perceptual asymmetries reflect developmental changes in the neuropsychological mechanisms of emotion recognition. Emotion. 2001; 1:84–98. [PubMed: 12894813]

Rose A, Rudolph KD. A review of sex differences in peer relationship processes: Potential trade-offs for the emotional and behavioral development of girls and boys. Psychological Bulletin. 2006; 132:98–131. [PubMed: 16435959]

Rudolph KD. Gender differences in emotional responses to interpersonal stress during adolescence. Journal of Adolescent Health. 2002; 30:3–13. [PubMed: 11943569]

Rudolph KD, Dennig MD, Weisz JR. Determinants and consequences of children's coping in the medical setting: Conceptualization, review, and critique. Psychological Bulletin. 1995; 118:328–357. [PubMed: 7501740]

Rudolph KD, Hammen C. Age and gender as determinants of stress exposure, generation, and reactions in youngsters: A transactional perspective. Child Development. 1999; 70:660–677. [PubMed: 10368914]

Sams M, Hietanen JK, Hari R, Ilmoniemi RJ, Lounasmaa OV. Face specific responses from the human inferior occipito-temporal cortex. Neuroscience. 1997; 70:49–55. [PubMed: 9044373]

Sergent J, Ohta S, MacDonald B. Functional neuroanatomy of face and object processing. Brain. 1992; 115:15–36. [PubMed: 1559150]

Shrout PE, Bolger N. Mediation in experimental and nonexperimental studies: New procedures and recommendations. Psychological Methods. 2002; 7:422–445. [PubMed: 12530702]

Smucker MR, Craighead WE, Craighead LW, Green BJ. Normative and reliability data for the Children's Depression Inventory. Journal of Abnormal Child Psychology. 1986; 14:25–39. [PubMed: 3950219]

Sobel, ME. Asymptotic intervals for indirect effects in structural equations models. In: Leinhart, S., editor. Sociological methodology 1982. San Francisco: Jossey-Bass; 1982. p. 290-312.

Sobel, ME. Some new results on indirect effects and their standard errors in covariance structure analysis. In: Tuma, N., editor. Sociological Methodology 1986. Washington, DC: American Sociological Association; 1986. p. 159-186.

Valera EM, Heller W, Berenbaum H. A twin study of individual differences in perceptual asymmetry. Laterality. 1999; 4:299–311. [PubMed: 15513119]

Voelz ZR, Gencoz F, Gencoz T, Pettit JW, Perez M, Joiner TE. Patterns of hemispheric perceptual asymmetries: Left hemispatial biases predict changes in anxiety and positive affect in undergraduate women. Emotion. 2001; 1:339–347. [PubMed: 12901396]

Weisz JR, McCabe M, Dennig MD. Primary and secondary control among children undergoing medical procedures: Adjustment as a function of coping style. Journal of Consulting and Clinical Psychology. 1994; 62:324–332. [PubMed: 8201070]

Wirsen A, Klinteberg B, Levander S, Schalling D. Differences in asymmetric perception of facial expression in free-vision chimeric stimuli and reaction time. Brain and Cognition. 1990; 12:229–239. [PubMed: 2340153]

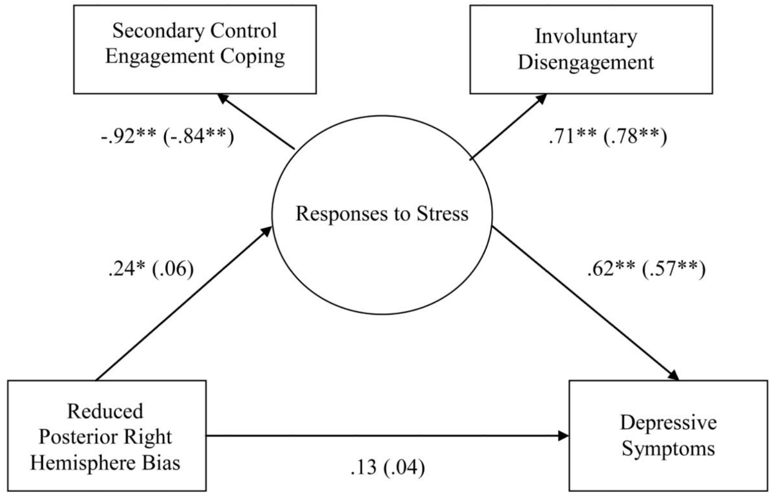

Figure 1.

Structural equation model of the associations among a reduced right hemisphere bias, responses to stress, and depressive symptoms. Path coefficients without parentheses are for the high-stress group; path coefficients in parentheses are for the low-stress group. * $p < .05$, ** $p < .01$.

Table 1

Intercorrelations Among the Measures

Measure	1	2	3	4	5	6	7
1. Reduced Right Hemisphere Bias	----	−.02	−.05	−.04	.08	.04	.07
2. Primary Control Engagement Coping	−.12	----	.09	−.39**	−.37**	−.47**	−.18**
3. Secondary Control Engagement Coping	−.20*	.33**	----	−.18**	−.69**	−.65**	−.48**
4. Effortful Disengagement	.02	−.38**	−.17	----	−.17**	.03	.08
5. Involuntary Engagement	.11	−.43**	−.76**	−.18	----	.42**	.36**
6. Involuntary Disengagement	.25*	−.57**	−.66**	.04	.37**	----	.45**
7. Depressive Symptoms	.28*	−.32**	−.60**	.09	.50**	.45**	----

Note. Intercorrelations for the low stress group are presented above the diagonal; intercorrelations for the high stress group are presented below the diagonal.

* $p < .05$.

** $p < .01$.