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Near-infrared spectroscopic study of frontopolar activation during face-to-face conversation in major depressive disorder and bipolar disorder

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ABSTRACT

Major depressive disorder (MDD) and bipolar disorder (BD) patients show speech characteristics that vary greatly according to mood state. In a previous study, we found impaired temporal and right inferior frontal gyrus (IFG) activation in schizophrenia during face-to-face conversation; no study had, however, previously investigated mood disorders during face-to-face conversation. Here, we investigated frontal and temporal lobe activation during conversation in patients with MDD and BD. Frontal and temporal lobe activation was measured using near-infrared spectroscopy (NIRS) in 29 patients with MDD, 31 patients with BD, and 31 normal controls (NC). We compared continuous activation and rapid change of activation with talk/listen phase changes during the conversation and analyzed the correlation between these indices and clinical variables. Both the MDD and BD groups showed decreased continuous activation in the left dorsolateral prefrontal (DLPFC) and left frontopolar cortices (FPCs); they also showed decreased rapid change in bilateral FPC activation. In the MDD group, the rapid change of activation was positively correlated with Global Assessment of Functioning (GAF) scores. In the BD group, continuous activation was negatively correlated with age of onset. These results indicate that frontal activation during conversation decreases in both MDD and BD. However, both continuous activation and rapid change may reflect the pathophysiological character of MDD and BD; in particular, the reduced amount of rapid change in the right FPC may be related to impaired adaptive ability in MDD.

1. Objectives of the study and background

Psychiatrists investigating mental illness can diagnose specific diseases using various characteristics exhibited by patients during the course of a conversation. Patients suffering from major depressive disorder (MDD) and bipolar disorder (BD) show particular conversational characteristics, which can be divided into those that do or do not change according to disease state (American Psychiatric Association, 1994; Bouhuys and Sam, 2000).

In the depressive state, patients use few words, show psychomotor retardation, and exhibit poor choices of conversation topics. Their emotional reactivity becomes poor, and smiles are not exhibited even when discussing pleasant topics. In contrast, in a manic or hypomanic state, patients with BD are more talkative than usual and speak one-sidedly; it may be difficult to understand the content of their speech due to the manifestation of flights of ideas. In the euthymic state, these symptoms disappear. Although these state-dependent characteristics of conversation are not specific to MDD and BD, it is essential to observe them because they are key to diagnosing these disorders using the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM–IV; American Psychiatric Association, 1994). These state-dependent characteristics are crucial in clinical assessments (Hamilton Rating Scale for Depression; Hamilton, 1960; Young Mania Rating Scale; Young et al., 1978).

There are several studies that investigated links between personality and social communication, as well as the direct communication between patients and interviewers. Patients with BD and MDD in the euthymic state have been found to differ from normal control (NC) participants in that they show high scores for harm avoidance and/or low scores for self-directedness and cooperativeness, as measured by the Temperament and Character Inventory (TCI; Celikel et al., 2009; Hansenne et al., 1999). With

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regards to direct communication, Coyne et al. stated that deficits in human communication play an important role in theories of development, persistence, and recurrence of depression (Coyne and Downey, 1991). Bouhuys et al. indicated that the lack of coordination during MDD interviews may be a risk factor for the condition's recurrence (Bouhuys and Sam, 2000). These characteristics may be associated with vulnerability in patients with mood disorders.

Cognitive and emotional dysfunctions underlying these characteristic conversational differences between healthy adults and mood disorder patients have been previously investigated by functional magnetic resonance imaging (fMRI). These studies suggest an altered activation of the amygdala, as well as the frontal, cingulate, and temporal cortices in patients with MDD and BD during various cognitive tasks (Savitz and Drevets, 2009). Although such data may assist in diagnosis, and may be directly related to the Global Assessment of Functioning (GAF), brain activation during conversation has not yet been investigated in patients with MDD and BD due to methodological difficulties.

Near-infrared spectroscopy (NIRS) is a recently developed noninvasive functional neuroimaging technique (Koizumi et al., 1999; Strangman et al., 2002). NIRS can detect regional cerebral blood volume (rCBV) changes through the fluctuating concentrations of oxyhemoglobin ([oxy-Hb]) and deoxyhemoglobin ([deoxy-Hb]). NIRS has some advantages over other functional neuroimaging methodologies due to (i) its complete noninvasiveness, enabling repeated measurements; (ii) the portability and compactness of the NIRS apparatus, enabling measurements under natural conditions with participants comfortably seated; and (iii) little sensitivity to motion artifacts, allowing the NIRS to be used in the study of conversation. Considering these advantages, NIRS allows for brain activation to be evaluated in a naturalistic environment. Indeed, several recent studies reported the use of NIRS during face-to-face interaction (Costantini et al., 2013; Cui et al., 2012; Konvalinka and Roepstorff, 2012).

Our group previously investigated frontal and temporal lobe activation during face-to-face conversations with normal control participants (Suda et al., 2010, 2011). Our results showed activity in the frontal and temporal lobes, as well as substantial cyclical activity in the frontal lobe corresponding to the time course of the conversation task — where participants were required to talk to a person facing them — especially around the frontopolar region. Both of these studies assessed only the sustained activities as grand average [oxy-Hb] data (GAOD) of the conversation and control tasks. In the present study, we sought to assess this substantial cyclical activity, measured by the averaged amount of [oxy-Hb] change (AAOC) over time. We measured this fluctuation in activity during the speech and listening phases superimposed on the base large [oxy-Hb] change during the task in order to evaluate the effects of switching turns during the conversation and control tasks. Although the meaning of the AAOC has not yet been clarified, we presumed that there are different physiological meanings assigned to the GAOD and AAOC. We posited that the GAOD represents the global functioning of an individual required to face to another person (i.e., a conversation situation-related function), while the AAOC mainly reflects speech itself (i.e., a speech-related function).

Because the characteristics of BD and MDD are well reflected in conversation, we hypothesized that (i) the GAOD and AAOC of the frontal cortex in MDD and BD would be altered compared to NC participants; and (ii) the GAOD or AAOC of the frontal cortex in MDD and BD would correlate with both GAF and depressive symptoms.

Table 1
Participant characteristics.

Sex (male)	MDD ($n = 29$)			BD ($n = 31$)			NC ($n = 31$)	
	M	F		M	F		M	F
	14	15		14	17		11	20
	Mean	SD		Mean	SD		Mean	SD
Age	34.5	9.0		34.9	6.6		33.6	10.0
Age range	19–51			20–45			23–58	
Age of onset	30.3	8.9		26.0	6.4		–	–
Illness duration	4.1	3.6		9.7	7.0		–	–
HRSD	9.8	4.4		6.4	5.5		–	–
YMRS	–	–		1.9	3.6		–	–
GAF	56.7	8.2		54.1	12.5		–	–
Subtype	–	–		BP I	1/31		–	–
	–	–		BP II	30/31			
	Mean	SD	*n*	Mean	SD	*n*		
Antidepressant (imipramine equivalent dose mg/day)	72.0	50.6	22/29	122.7	85.2	17/31	–	–
Antipsychotic (chlorpromazine equivalent dose mg/day)	112.5	63.5	6/29	213.5	122.8	11/31	–	–
Anxiolytic (diazepam equivalent dose mg/day)	7.1	6.4	14/29	12.6	17.2	15/31	–	–
Hypnotic (flunitrazepam equivalent dose mg/day)	2.0	1.5	16/29	2.5	2.0	16/31	–	–
Lithium mg/day	300.0	–	1/29	618.8	242.8	16/31	–	–
Carbamazepine mg/day	0	–	0/29	500.0	258.2	4/31	–	–
Valproate mg/day	300.0	200.0	2/29	552.9	194.0	17/31	–	–

M, male; F, female; MDD, major depressive disorder; BD, bipolar disorder; NC, normal controls; BPI, bipolar I disorder; BPII, bipolar II disorder; HRSD, 17-item Hamilton Rating Scale for Depression; YMRS, Young Mania Rating Scale; GAF, The Global Assessment of Functioning.

2. Materials and methods

2.1. Sample

Twenty-nine patients with MDD, 31 patients with BD, and 31 healthy volunteers (NC) were recruited from the Department of Psychiatry and Neuroscience of Gunma University Hospital in Japan to participate in this study. All participants were right-handed native Japanese speakers. Participants had been previously diagnosed with MDD or BD according to the DSM-IV criteria (American Psychiatric Association, 1994). Patients over 60 years old were not included in this study in order to eliminate the effects of additional pathophysiological factors such as aging and possible cerebrovascular changes. Depressive symptoms among patients with MDD and BD were evaluated using the 17-item Hamilton Rating Scale for Depression (HRSD; Hamilton, 1960). Manic symptoms in BD patients were evaluated using the Young Mania Rating Scale (YMRS; Young et al., 1978). Nearly all participants were on medication such as mood stabilizers, antipsychotics, antidepressants, anxiolytics, and/or hypnotics. Equivalent dosages were calculated for each class of medication, as follows: chlorpromazine-equivalent dose of antipsychotics; imipramine-equivalent dose of antidepressants; diazepam-equivalent dose of anxiolytics; and flunitrazepam-equivalent dose of hypnotics (Inagaki and Inada, 2006).