Neurocognition in Unaffected First-Degree Relatives of Patients With Bipolar Disorder Type I From India: A Potential Vulnerability Marker?

Raman Deep Pattanayak¹, Rajesh Sagar¹, and Manju Mehta¹

Abstract
The study aims to evaluate the neuropsychological functions of unaffected first-degree relatives of patients with bipolar disorder Type I (BD-I) in comparison with healthy controls. The method was a cross-sectional assessment of 20 first-degree relatives of patients with BD-I and 20 healthy controls. Inclusion criteria for all participants included age between 18 and 55 years, ≥5 years of formal education, right-handedness as per Edinburgh handedness inventory, absence of color blindness as per Ishihara’s isochromatic charts, and a score of >24 on Hindi mental state examination. None of the participants had a current or lifetime diagnosis of a mental disorder on Structured Clinical Interview for DSM-IV, Clinician Version. Neuropsychological assessment was conducted with Trail Making Test A and B, Stroop color and word test, N-Back Verbal Memory Test, and Post Graduate Institute (PGI) Memory Scale. Both the groups were comparable in age, gender distribution, and education. The unaffected first-degree relatives performed poorly on Trail Making Test B and (B-A), indicating a poor cognitive flexibility and set-shifting. The relative group also performed poorly on Mental Balance subtest of PGI Memory Scale. The unaffected first-degree relatives of patients with BD display certain impairments in dorsal prefrontal executive functions which can serve as vulnerability markers for BD.

Keywords
psychiatry, behavioral sciences, neurocognition, first-degree relatives, bipolar disorder, cognitive deficits

Introduction
Research over the past few years has revealed the presence of cognitive deficits in euthymic phase of bipolar disorder Type I (BD-I; Robinson et al., 2006; Torres, Boudreau, & Yatham, 2007). These cognitive deficits are independent of a mood state and have been proposed to a trait marker for BD (Torres et al., 2007). The first-degree relatives of bipolar sufferers have been shown to have a 10- to 20-fold increase in the risk of developing BD themselves (Merikangas et al., 2002). It is important to examine the neuropyschological performance of first-degree relatives of bipolar patients to assess whether cognitive impairments are indeed a trait-like feature of the disorder and present in unaffected, at-risk family members. In order for a marker to be considered as a vulnerability marker (endophenotype), it must be associated with illness, must be present in asymptomatic patients, should be heritable, and must be observed among unaffected relatives (Gottesman & Gould, 2003). The neurocognitive deficits present in unaffected first-degree relatives of bipolar probands may serve as endophenotypes for the disorder, particularly if the biological relatives exhibit these deficits. More recent studies in apparently healthy relatives of patients with BD have found certain cognitive deficits, indicating impairments in verbal memory and executive functions, for example, response inhibition and set-shifting (Bora et al., 2008; Frantom, Allen, & Cross, 2008; Kulkarni, Jain, Janardhan Reddy, Kumar, & Kandavel, 2010). Mixed evidence has emerged for psychomotor speed and sustained attention deficits in relatives. The healthy monozygotic twin of bipolar probands were found to have dysfunctions in language, memory, executive functions, sustained attention, and working memory (Christensen, Kyvik, & Kessing, 2006; Kieseppa et al., 2005). More studies are needed to evaluate the nature and type of cognitive deficits in family members of BD. Furthermore, the cognitive endophenotypes may differ in an ethnically diverse population and need to be investigated in diverse settings.

¹All India Institute of Medical Sciences, New Delhi, India

Corresponding Author:
Raman Deep Pattanayak, Senior Research Associate (CSIR), All India Institute of Medical Sciences, Ansari Nagar, New Delhi 110029, India
Email: drraman@hotmail.com
The study aimed to assess the neuropsychological functions in unaffected first-degree relatives of patients with BD and compare them with healthy controls.

**Method**

**Study Setting**

The study was conducted at the outpatient clinic in Department of Psychiatry at a premier medical institute for teaching and patient care in India. Ethical approval for the study was taken from the Institutional Ethics Committee.

**Study criteria**

The present study was a cross-sectional assessment of 20 unaffected first-degree relatives of patients with BD-I and 20 healthy controls. Inclusion criteria for both relatives and controls included an age range between 18 and 55 years, minimum 5 years of formal education, right-handedness established by Edinburgh Handedness Inventory (Oldfield, 1971), absence of color blindness on testing by Ishihara’s isochromatic charts (Ishihara, 1917) and a score of >24 on Hindi mental state examination (HMSE; Ganguli et al., 1995). The participants in the relative group were a first-degree blood relative to the BD-I patient, whose diagnosis was established by a psychiatrist using Structured Clinical Interview for DSM-IV, Clinician Version (SCID-CV; First, Spitzer, Gibbon, & Williams, 1996). Exclusion criteria for all the participants included a current or lifetime diagnosis of a major psychiatric disorder as per SCID-CV or substance dependence other than nicotine, a history of significant head injury, and medical or neurological disorder.

The control group included healthy persons with absence of any psychiatric diagnosis based on SCID-CV (First et al., 1996), absence of substance dependence other than nicotine, absence of medical or neurological disorder, and a negative family history of psychiatric illness. Controls were recruited from among the staff members, hospital employees, friends of patients, or willing persons from community. None of the participants had taken any kind of medication in the 24 hr prior to cognitive assessment, to ensure that the participants’ psychomotor activity and reaction were not impaired.

**Study Procedure**

The participants fulfilling the selection criteria were approached for inclusion. After written informed consent, the principal author performed the evaluation and assessments for each participant in a single session. The sessions were conducted in first half of the day in quiet surroundings with minimum distraction. The participants were offered to take a 5-min break after an hour but were not permitted to smoke or consume caffeinated drinks. The assessor was not blind to the status of the participant.

**Assessments**

After a careful selection by SCID-CV, Edinburgh’s handedness inventory, Ishihara’s color charts, and HMSE as mentioned earlier, the participants were assessed by using the following tools:

Semistructured proforma. A semistructured proforma was used to gather sociodemographic, personal, and family details of all participants.

Trail Making Test A and B (TMT-A & B). The TMT (Smith & Jonides, 1999) reflects the visuocognitive and visuomotor functions. The TMT consists of two parts: Part A measures visual attention and psychomotor speed; Part B measures cognitive flexibility and task switching. It requires a participant to “connect-the-dots” of 25 consecutive targets on a sheet of paper. In Part A, the targets are all numbers (1, 2, 3, etc.) and in Part B, the participant alternates between numbers and letters (1, A, 2, B, etc.). The goal is to finish the test as quickly as possible and the completion time is used as the primary performance metric. The derived score, TMT (B-A) is calculated as the difference in time taken to complete the TMT-A and TMT-B tests and is also an indicator of prefrontal functioning.

Verbal Working Memory N-Back Test. This test (Mukunda, 1994) is based on theoretical premise that two variables, namely, word length and phonemic similarity, can affect verbal working memory. A total of 30 randomly ordered consonants common to multiple Indian languages were presented verbally at the rate of one per second and the participant is required to respond by tapping the table for phonetically similar sounds. In 1-back task, the participant responds for consecutively repeated sounds and in 2-back task, the participant responds if the sound is repeated after an intervening phoneme. The number of hits and errors (both omissions and commissions) comprise the score, which is indicative of the internally guided working memory.

Stroop color and word test (SCWT). The SCWT (Golden, 1978) measures the relative speeds of reading the names of colors (word card), naming colors (color card), and identifying color names that are printed in another color (color interference card; CI). The last task has an interference component because it requires the participant to override or inhibit a reading response. This test measures the ease with which a person can shift his or her perceptual set to conform to changing demands and inhibit usual response from interfering with the unusual one. The test is essentially a measure of cognitive flexibility and response inhibition.

PGI Memory Scale. The PGI Memory Scale (Pershad & Verma, 1990) is part of the PGI battery of brain dysfunction and has been developed in India. The battery is administered in Hindi, the national language, and has been validated for use in the Hindi-speaking population. It is a comprehensive scale to measure verbal and nonverbal memory and has been extensively used in Indian studies. It consists of 10 subtests for remote memory, recent memory, mental balance, attention and concentration (digit span), delayed recall, immediate
Table 1. Sample Characteristics: First-Degree Relatives (n = 20) and Healthy Controls (n = 20)

|                  | Relatives | Controls | t     | p     |
|------------------|-----------|----------|-------|-------|
| Age (years)      | 30.70 ± 11.43 | 33.25 ± 10.41 | 0.738 | .465  |
| Gender (% M:F)   | 60:40     | 60:40    |       |       |
| Education (years)| 12.20 ± 3.02 | 13.05 ± 3.79 | .784  | .438  |
| HMSE             | 28.10 ± 1.07 | 28.60 ± 1.27 | 1.344 | .187  |

Note: HMSE = Hindi mental state examination. Statistical analysis by independent-samples t test.

Results

There was no significant difference in age, gender distribution, education, and HMSE of relatives and controls as shown in Table 1. Majority of the sample (75% of relatives and 80% of controls) was from middle socioeconomic status and the rest were from lower socioeconomic status. The relative group had nine (45%) siblings, seven sons (35%), and four parents (20%) of the patient. All the participants in the relatives group had ≥1 first-degree relative who had been diagnosed to be suffering from BD-I. Six (30%) of the participants in relative group had 2 first-degree relatives with BD and five had a second-degree relative with BD in addition to a first-degree relative.

Tables 2 and 3 show the performance of relative and control group on the tests of attention/psychomotor processing speed (TMT-A, Mental Balance Memory subtest, SCWT word and color cards), executive functions (TMT-B, SCWT), and working memory (N-back). There is a significant difference in the TMT-B, TMT (B-A), and Mental Balance subtest of PGI Memory Scale, with relatives performing poorly compared with controls. It is to be noted that the log-transformed variables have been used in Table 2, which have been computed to ensure normality.

Discussion

The findings reveal cognitive deficits in unaffected relatives of individuals with BD in accordance with the study hypothesis. Both the groups were comparable in sociodemographic parameters and were rigorously assessed to rule out a current or lifetime psychiatric diagnosis. The findings indicate presence of specific, rather than a generalized, cognitive dysfunction in the unaffected first-degree relatives, which could represent a trait or vulnerability marker.

The relatives performed poorly on TMT-B and TMT (B-A) compared with healthy controls. Deficits were observed in the set-shifting ability and cognitive flexibility, which are a part of executive functioning. The finding is in consonance with some of the previous studies showing impairments of TMT-B in unaffected relatives (Arts, Jabben, Krabbendam, & van Os, 2008; Christensen et al., 2006; Szoke et al., 2006). The executive dysfunction has been seen in unaffected relatives as well as euthymic patients of BD-I and is considered to be a potential vulnerability marker (Arts et al., 2008). However, literature so far has been inconsistent on the type of executive function tasks that are impaired in relatives, with some studies revealing deficits in TMT-B as well as response-inhibition tasks (Antila et al., 2007; Zalla et al., 2004), while other studies suggest a deficit in response inhibition only (Frangou, Haldane, Roddy, & Kumari, 2005). The response-inhibition deficits, indicative of possible abnormalities in ventromedial prefrontal cortex (VPFC) and cingulate function, have been proposed to be one of vulnerability markers for BD-I (Bora, Yucel, & Pantelis, 2009). In contrast, the findings from the present study suggest deficits in set-shifting and mental flexibility, pointing to the role of dorsal prefrontal cortical (DLPFC) dysfunction. The study adds to previous studies that have suggested an impairment of set-shifting as a potential familial vulnerability marker for the BD-I. It is also noteworthy that the impairments of set-shifting ability have also been considered as a candidate intermediate phenotype marker for schizophrenia, though the results from some of recent studies (Ceaser et al., 2008) suggest that impairments on attentional set-shifting may be more strongly associated with clinical illness in patients rather than their unaffected relatives. Therefore, the investigation of executive functions as a cognitive endophenotype of BD-I disorder needs to be done more rigorously in carefully planned studies.

So far, only two published studies from India (Kulkarni et al., 2010; Trivedi et al., 2008) have assessed the cognitive functions in unaffected relatives of individuals with BD. The study by Trivedi et al. (2008) found impairments of the set-shifting in relatives similar to present study, with additional deficits in problem solving, planning, and vigilance. The study by Kulkarni et al. (2010) found deficits in verbal learning and memory, which was largely preserved in present
It may be due to differing sample characteristics and use of different type of instruments to assess memory functions in both the studies. Furthermore, the present study assessed cognitive functioning of any first-degree unaffected relative compared with unaffected siblings only in the study by Kulkarni et al., which may have contributed to the difference. This study sheds light on the pattern of cognitive deficits in first-degree relatives of individuals with BD-I from Asian region.

The present study has demonstrated an intact functioning of verbal and nonverbal memory in relatives. Absence of memory deficits as in this study is consistent with some of the previous studies (Antila et al., 2007; Clark, Sarna, & Goodwin, 2005), though a recent meta-analysis of 14 studies of relatives of BD has suggested a small but significant effect size for verbal memory deficits (Arts et al., 2008). The Mental Balance subtest in PGI Memory Scale (administration of three tasks, viz., speaking alphabets in order, backward counting from 20 to 0, and serial subtractions, scored for time taken and errors) showed significantly lower scores in relatives compared with controls. While the specific tasks for attention and concentration (digit span) and psychomotor speed (TMT-A) did not show any deficits in relatives, the presence of impaired Mental Balance subtest needs to be investigated further.

The present study has several important implications for bipolar research. The findings suggest that deficits in the set-shifting and cognitive flexibility may be an endophenotype marker for BD-I. Consistent with criteria for endophenotypic markers, these cognitive deficits are known to be associated

Table 2. Neuropsychological Performance in First-Degree Relatives and Controls: Tests for Attention, Psychomotor Processing Speed, and Executive Functions

| Log-transformed data* | M ± SD | M ± SD | t | p | Effect size |
|-----------------------|--------|--------|---|---|-------------|
| **Time taken**        |        |        |   |   |             |
| **TMT**               |        |        |   |   |             |
| TMT-A                 | 3.76 ± 0.50 | 3.77 ± 0.41 | 0.074 | .942 | 0.010       |
| TMT-B                 | 5.01 ± 0.54 | 4.69 ± 0.51 | 2.058 | .047* | 0.291       |
| TMT (B-A)             | 4.62 ± 0.62 | 4.19 ± 0.50 | 2.381 | .022* | 0.357       |
| **Stroop color and word test** |        |        |   |   |             |
| Word card (S1)        | 3.99 ± 0.25 | 3.96 ± 0.21 | 0.515 | .610 | 0.065       |
| Color card (S2)       | 4.53 ± 0.32 | 4.47 ± 0.30 | 0.646 | .522 | 0.096       |
| Color word card (S3)  | 5.02 ± 0.28 | 5.20 ± 0.39 | 1.693 | .099 | 0.256       |
| Interference score (S3-S1) | 4.57 ± 0.36 | 4.84 ± 0.48 | 2.031 | .055 | 0.303       |

Note: TMT = Trail Making Test. Statistical analysis by independent-samples t test.

Table 3. Neuropsychological Performance in First-Degree Relatives and Controls: Tests for Memory

| Verbal Working Memory N-Back Test |        |        |   |   |             |
|----------------------------------|--------|--------|---|---|-------------|
| 1-back hits                      | 8.05 ± 1.15 | 8.45 ± 0.83 | 1.267 | .213 | 0.399       |
| 1-back errors                    | 1.25 ± 1.12 | 1.10 ± 1.88 | 0.306 | .762 | 0.096       |
| 2-back hits                      | 6.50 ± 1.82 | 6.15 ± 1.95 | 0.586 | .561 | 0.186       |
| 2-back errors                    | 3.10 ± 2.10 | 3.00 ± 1.89 | 0.158 | .875 | 0.050       |
| **PGI Memory Scale subtests**    |        |        |   |   |             |
| Mental Balance                   | 6.80 ± 1.19 | 7.75 ± 1.25 | 2.454 | .019* | 0.778       |
| Attention and Concentration      | 8.90 ± 2.29 | 9.15 ± 1.31 | 0.424 | .674 | 0.134       |
| Immediate Recall                 | 8.35 ± 1.66 | 9.25 ± 1.16 | 1.983 | .056 | 0.628       |
| Delayed Recall                   | 10.35 ± 1.73 | 10.85 ± 1.14 | 1.082 | .286 | 0.341       |
| Verbal Retention for Similar Word-Pairs | 4.70 ± 0.97 | 4.90 ± 0.31 | 0.872 | .389 | 0.278       |
| Verbal Retention for Dissimilar Word-Pairs | 11.70 ± 2.79 | 12.30 ± 2.43 | 0.725 | .473 | 0.229       |
| Visual Retention                 | 11.15 ± 2.30 | 11.00 ± 2.24 | 0.209 | .836 | 0.066       |
| Recognition                      | 9.40 ± 1.05 | 9.75 ± 0.55 | 1.324 | .196 | 0.418       |

Note: Statistical analysis by independent-samples t test.

*The variables have been computed from raw data using natural log to ensure normality.
*p < 0.05
with illness and found in euthymic patients (Robinson et al., 2006; Torres et al., 2007). Defining the cognitive endophenotypes of BD and using them to probe susceptibility genes for BD might be a useful strategy to understand the complex genotype of mood disorders. The subtle cognitive deficits in one or more domains may interfere with the daily functioning and quality of life of an individual. It is, therefore, important to undertake further research on the functional implications of the cognitive deficits in the first-degree relatives.

The study has some limitations. The sample size was small and recruited from a hospital setting. The first-degree relatives comprised of siblings, parents, and children, and it is possible that restriction to biological siblings or offsprings may have revealed a different pattern of deficits. The corrections for multiple comparisons to reduce risk of Type I error were not used. The study, however, has overcome some limitations of previous studies. The diagnosis of BD-I patient, whose first-degree relative was included in the study, was firmly established by a psychiatrist using a SCID to avoid any ambiguity. The neuropsychologist tests employed in the study are culture specific and have been used extensively in Indian psychiatric research.

To conclude, the study suggests presence of some deficits in executive functions in first-degree relatives of BD-I patients, which could be a potential marker for familial vulnerability of BD-I.

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**Bios**

**Raman Deep Pattanayak** M.D. is a Pool Officer in Dept of Psychiatry, AIIMS. Her areas of research so far include cognitive endophenotypes of bipolar disorder, dementia caregiver burden and role of urinalysis in substance use disorders.

**Rajesh Sagar** M.D. is an Additional Professor, Dept of Psychiatry, AIIMS. His areas of research include Child psychiatry, Neurocognition in psychiatric disorders and Psychiatric epidemiology.

**Manju Mehta** Ph D. is a Professor of Clinical Psychology, AIIMS. Her areas of research include Child and Adolescent Psychiatry, Neurocognition of Psychiatric disorders and Cognitive Behavioral therapy.