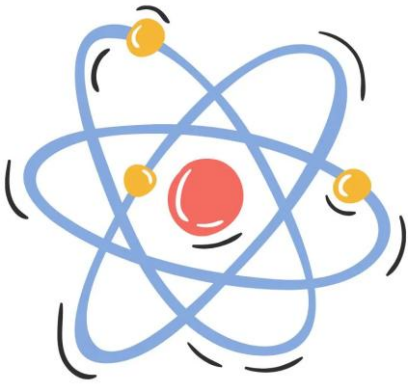

ISSN: 1672 - 6553

JOURNAL OF DYNAMICS AND CONTROL

VOLUME 10 ISSUE 06: P73-98

# COGNITIVE FUNCTIONING IN BIPOLAR AFFECTIVE DISORDER WITH AND WITHOUT ALCOHOL DEPENDENCE: A COMPARATIVE ANALYSIS

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JOURNAL OF DYNAMICS AND CONTROL
https://doi.org/10.71058/jodac.v10i06006

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***Abstract:*** *Bipolar affective disorder (BPAD) paired with comorbid alcohol dependence syndrome (ADS) is a chronic illness which is characterised by mood swings, cognitive losses and functional disabilities. In the present investigation neuropsychological performance in patients of different age groups, education, domicile and socio-economic status was compared with respect to BPAD and BPAD comorbid with ADS. Total 30 participants were selected for this study including 17 with BPAD and 13 with BPAD+ADS. Standard neuropsychological tests including PGI memory scale, token test, vigilance, logical memory, Wisconsin card sorting, auditory verbal learning, digit substitution, verbal working memory and triads test performed on the both the study groups revealed that individuals between the age group of 30-40 years residing in the urban areas with middle economic status were vulnerable to the occurrence of the BAPD and BPAD + ADS. This group also showed relatively poor performance in comprehension, memory and attention tests. The results also revealed that the occurrence of these additional disorders alongwith the primary symptoms such as strong desire and uncontrolled uses of alcohol are related to a specific cognitive domain and further research on a larger population affected with BPAD and BPAD + ADS can help in advance prognosis of both the disorders.*

***Keywords:*** *Bipolar disorders, alcohol dependence syndrome, cognitive losses, memory and comprehension*

https://doi.org/10.71058/jodac.v10i06006

# 1. Introduction

## 1.1. Bipolar Affective Disorder: Clinical Features and Cognitive Sequelae

Bipolar affective disorder (BPAD) is commonly characterised by repetitive recurrent episodes of mania and hypomania and depression (McIntyre et al., 2020; Tondo et al., 2017). It has been reported that approximately 1-3% of the global population is affected by this severe psychiatric condition (Association, 2013) (American Psychitic Association 2013). Several research reports in the past 2 decades have shown that BPAD is associated with the occurrence of cognitive impairments alongwith mood swings and continued illness which directly affect the day-to-day functionality, occupational outcomes and reduce the life quality of a person (Baburaj, 2025; Huang et al., 2023; Simjanoski et al., 2022). Moreover, significant loss in the verbal memory and executive functions which persist in the nonacute stages are also characteristic symptoms of BPAD (Kumar et al., 2024; Lopes & Fernandes, 2012; Rinita & KantiPudi, 2023; van Gorp et al., 1998).

BPAD also hampers the continuous learning and attentional process of the individual which directly cause slow learning and reduced analytical strength (Aswathi, 2022; Naskar, 2024; Raipure, 2021). Reports have also shown the presence of heterogeneity in the neurocognitive profiles of the BPAD patients including 2 subtypes (type I and type II) in which BP-Type I is causing higher losses to memory and analytical functions (Bora, 2018; Simonsen et al., 2008). The basic research in the area of the neurocognitive impairment and dysfunction has revealed that BPAD are related to the abnormalities in the prefrontal cortex and neural networks (Berdahl, 2010; Bi et al., 2022; Savitz et al., 2014).

Apart from this BPAD associated with the alcohol dependence syndrome (ADS) has also gained attention in recent past due to its repeated behavioural and cognitive responses of strong desire of alcohol consumption and uncontrolled uses of alcohol, despite of life-threatening repercussions (Chikritzhs et al., 2024). This causes severe effects on the central nervous system (CNS) resulting in structural alterations and functional impairments at various cognitive levels such as memory systems, visuospatial abilities and neuro-muscular activities (Bearden et al., 2001; Lagerberg et al., 2017).

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In several reports it has been revealed through series of tests including Wisconsin Card Sorting Test (WCST) and Stroop-like measures that memory impairments encompass verbal as well as visual abilities, encoding and consolidation and other retrieval process (Gómez, 2024; Jodzio & Biechowska, 2010; Zimmermann et al., 2015).

Multiple factors contribute to the severity and pattern of these neuro-cognitive disorders such as duration and quantity of alcohol uses, age of the individual, nutritional status and also the genetic makeup (Bernardin et al., 2014; Cipriani et al., 2017; Evert & Oscar-Berman, 1995; Latalova et al., 2011; Levy, 2013; Mayfield et al., 2008; Ramanath et al., 2023; Vieta et al., 2013).

The simultaneous occurrence of the BPAD and ADS with a substantial increasing rate is a clinical challenge nowadays. The recent epidemiological studies have reported that the individual suffering with BPAD have a high rate of co-occurrence of BPAD and ADS as they show a complex and bidirectional relationship (Beyond, 2022; Ramanath et al., 2023; Rich & Martin, 2014; Shivhare et al.). Researchers have proposed several mechanisms to explain this combination including self-medication hypotheses (Blume et al., 2000; Bolton et al., 2009; Khantzian, 1997; Lembke, 2012) shared genetic vulnerabilities (Greenwood, 2020; Nery et al., 2013; Richards et al., 2022), overlapping neurobiological substrates (Charney et al., 2020; Goodkind et al., 2015; McCrea, 2008) disinhibiting effects of manic (Söderpalm, 2002). The role of mechanisms in the dual diagnosis is substantial and multifaceted because the onset of illess, various disabilities and rate of hospitalization is high in the patients with BPAD + APD as compared to those with either disorder alone.

Authors describe a bidirectional detrimental interaction in which alcohol dependence worsens cognitive and functional outcomes in bipolar disorder and vice versa, producing a negative clinical cycle. The presence of alcohol dependence complicates the pharmacological management of bipolar disorder, as alcohol can interfere with medication efficacy, increase side effects, and contribute to medication non-adherence. Additionally, the neurotoxic effects of chronic alcohol use may compound the cognitive deficits already present in bipolar disorder, potentially resulting in more severe and persistent neuropsychological impairments (Cipriani et al., 2017; Gogia et al., 2022; Latalova et al., 2011).

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Despite the high occurrence and severe cognitive disabilities of this combination (BPAD + ADS), studies on the direct comparison of the neurophysiological and cognitive functioning among the patients with BPAD alone and those with comorbid BPAD and ADS are limited. Recent reports have focussed on one particular disorder alongwith a substance as a co-variant rather than examining it as a primary variable. Moreover, most of the studies have conducted in Western part of the globe with very less information on the diversified cultural contexts (Balanzá-Martínez et al., 2010; Dias et al., 2012; Oliva et al., 2025).

In the proposed investigation these gaps have been addressed through a comprehensive comparison of neuropsychological conditions among the patients with BPAD and patients with BPAD+ADS using nine standardized tests. This study aims provide an elaborated cognitive profile of both groups and to identify domain vulnerability in the dual-diagnosis population which may be important for the further research on the clinal assessment, treatment measures and novel rehabilitation interventions for the specific population suffering with combined disorders of BPAD + ADS.

## 2. Methodology

### 2.1. Study Design

The present research provides investigation of comparative occurrence between two different groups to evaluate cognitive and neuropsychological disorders in BPAD patients and patients with BPAD + ADS. The study was performed in an inpatient psychiatric setting, allowing the controlled assessment conditions and verification of diagnostic status.

### 2.2. Participants

The study was comprised of 30 individuals divided in 2 different groups:

(i) BPAD group N = 17

(ii) BPAD + ADS group N = 13

(N = number of participants)

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### 2.3. Inclusion Criteria

Following inclusion criteria were accepted for the study:

(i) Age range : 18-60 years

(ii) Confirmed diagnosis of BPAD and (Type I or Type II) according to ICD-10 or DSM-IV-TR criteria

(iii) BPAD+ADS group: Concurrent diagnosis of ADS according to ICD-10 or DSM-IV-TR criteria

(iv) Clinical stability to complete neuropsychological testing

(v) Informed consent of the participants

(vi) Proficiency in language of test administration

### 2.4. Exclusion Criteria

(i) History of neurological disorders e.g., epilepsy, brain injury or stroke etc.

(ii) Current or past diagnosis of other psychotic disorders (excluding mood-congruent psychotic features in bipolar disorder)

(iii) Intellectual disability or developmental disorders

(iv) Severe medical conditions affecting cognitive function

(v) BPAD group: Current or past dependence on alcohol or other substances (excluding nicotine)

(vi) Electroconvulsive therapy within the past 6 months

(vii) Sociodemographic Characteristics

### 2.5. Neuropsychological Assessment Battery

A comprehensive set of neuropsychological tests series was administered to assess multiple cognitive domains. This included the following standardized tests:

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**Table 1** Details of the neuropsychological tests administered to the participants

| | **Purpose** | **Domains assessed** | **Administration** | **Scoring** |
|---|---|---|---|---|
| **PGI-Memory Scale** | Assessment of general memory function across multiple dimensions | Remote memory, recent memory, immediate memory, attention, concentration, recognition, mental balance, and retention | Standardized administration according to test manual | Total score reflecting overall memory capacity |
| **Token Test** | Evaluation of auditory comprehension and receptive language abilities | Understanding of verbal commands of increasing complexity | Patient follows verbal instructions involving manipulation of tokens varying in size, shape, and color | Total correct responses |
| **Digit Vigilance Test** | Assessment of sustained attention and vigilance | Selective attention, concentration, and response consistency | Participant identifies target digits from an array over an extended period | Accuracy and consistency measures |
| **Logical Memory Test** | Evaluation of immediate and delayed narrative memory | Immediate recall and delayed recall of story information | Stories are read aloud; participant recalls immediately and after delay | Number of story elements correctly recalled |
| **Wisconsin Card Sorting Test (WCST)** | Assessment of executive function, particularly cognitive flexibility and set-shifting | Abstract reasoning, perseveration, ability to shift cognitive sets | Participant sorts cards according to rules that change without explicit notification | Categories achieved, perseverative errors, and other executive function indices |
| **Auditory Verbal Learning Test (AVLT)** | Evaluation of verbal learning and memory across multiple trials | Immediate memory span, learning curve, interference effects, delayed | List of words presented across multiple learning trials, with | Total words learned across trials, delayed recall, |

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| | | | | |
|---|---|---|---|---|
| | | recall, recognition | interference list and delayed recall | recognition accuracy |
| **Digit Substitution Test** | Assessment of psychomotor speed, attention, and working memory | Processing speed, sustained attention, visual scanning | Participant substitutes symbols for digits according to a key, working as quickly as possible | Number of correct substitutions within time limit |
| **Verbal Working Memory Test** | Evaluation of working memory capacity for verbal information | Maintenance and manipulation of verbal information in working memory | Tasks requiring holding and manipulating verbal information (e.g., digit span backward, letter-number sequencing) | Span length or total correct trials |
| **Trails Test (Trail Making Test)** | Assessment of visual attention, processing speed, and cognitive flexibility | Visual scanning, psychomotor speed, divided attention, set-shifting (if Part B included) | Participant connects numbered circles in sequence (Part A) or alternates between numbers and letters (Part B) | Time to completion, errors |

### 2.6. Procedure

Participants for the present investigation were identified by through clinical recommendations. The research staff approached the potential patients and explained the objectives of the study and invited them to participate. A written consent was a;so obtained from each member of the study groups prior to start of the test procedure.

To establish the diagnostics confirmation, clinical interviews were conducted by qualified psychiatrists. Standard diagnostic criteria (ICD-10 or DSM-IV-TR) as per previous reports were used for the study (First, 1997; Muschalla & Linden, 2012; Sheehan et al., 1998). The patients meeting the exclusion criteria as per their medical records were excluded from the test groups. For the participants of the BPAD+ADS group, diagnosis of

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alcohol dependence was accessed by clinical assessment and the data regarding the severity and duration of alcohol consumption and was recorded.

All the neuropsychological tests were performed in a quiet and closed, well-lit and silent testing chamber. All the assessments were conducted under constant supervision of psychiatrists. The test series was administered in a standard order and breaks were also provided in regular intervals to prevent fatigue. The duration of each testing session was set upto 2-3 h. All the tests were conducted ion the clinically stable condition of the participants (i.e. no occurrence of acute maniac episode or state of severe depression) to avoid any side-effect on the cognitive assessment and the data of the current state of mind was recorded.

### 2.7. Statistical Analysis

All the datasets were statistically analyzed using the SPPS software version .... Descriptive statistics including means and standard deviation were calculated for the scores obtained for all neuropsychological tests for both groups. Independent samples t-tests were also conducted to compare mean performance between the BPAD and BPAD+ADS groups on each neuropsychological measure. The significance level was set at p = 0.05 for all analyses.

Effect sizes were calculated using Cohen's *d* (Cohen, 1977) to measure the significance or magnitude of differences between the groups independent of sample size using the following formula:

$$d = \frac{M_1 - M_2}{SD_{pooled}}$$

where

$M_1$ and $M_2$ = means for the two groups

$SD_{pooled}$ = Pooled Standard Deviation.

Effect sizes (interpreted as per the standard guidelines) Cohen 1977:

Small d = 0.20

Medium d = 0.50

Large d = 0.80

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Due to the exploratory nature of the study, multiple comparisons were not conducted, although, the patterns of results obtained across the tests and the magnitude of the effect were taken into account to determine the clinical significance of the results.

## 3. Results

### 3.1. Sociodemographic Characteristics

The sociodemographic analysis (Figure 1, Table 2) analysis of variables revealed patterns of vulnerability within the sample. The patients with education upto $10^{th}$ standard showed highest frequency in both the test groups, which suggests that the education level may be considered as a vulnerability factor. Further, patients with the range of 30-40 years were more affected which shows that the persons within this range show the typical symptoms of the illness and development of comorbidity. In both categories, people lived in cities than in rural areas showed more prevalence, may be due to the ease of access to the professional psychiatric care. Further, middle class and married persons working in private sector were most prevalent.

Geographic analysis revealed that participants from urban areas were more prevalent than those from rural settings in both the BPAD and BPAD+ADS groups, potentially reflecting differential access to specialized psychiatric services or help-seeking patterns. Socioeconomic status analysis indicated that individuals from middle-class backgrounds constituted the largest proportion of both groups. Marital status distribution showed that married individuals were most represented in the sample. Occupational analysis revealed that persons employed in the private sector were the most common in both diagnostic groups, suggesting this occupational category may represent a cause for vulnerability to these disorders.

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**Table 2** Demographic Details of the Patients

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| **Education** | | | | | |
| | Valid | 1 | 3.23 | 3.23 | 3.23 |
| | X | 12 | 38.71 | 38.71 | 41.94 |
| | XII | 7 | 22.58 | 22.58 | 64.52 |
| | Graduation | 7 | 22.58 | 22.58 | 87.10 |
| | Post Graduation | 4 | 12.90 | 12.90 | 100.00 |
| **Domecile** | | | | | |
| | Valid | 1 | 3.2258 | 3.23 | 3.23 |
| | Rural | 10 | 32.258 | 32.26 | 35.48 |
| | Urban | 20 | 64.516 | 64.52 | 100.00 |
| **Age Range (Years)** | | | | | |
| | Valid | 1 | 3.23 | 3.23 | 3.23 |
| | 20-29 | 3 | 9.68 | 9.68 | 12.90 |
| | 30-39 | 14 | 45.16 | 45.16 | 58.06 |
| | 40-49 | 9 | 29.03 | 29.03 | 87.10 |
| | 50-59 | 4 | 12.90 | 12.90 | 100.00 |
| **Socio-Economic Status** | | | | | |
| | Valid | 1 | 3.23 | 3.23 | 3.23 |
| | Lower Class | 4 | 12.90 | 12.90 | 16.13 |
| | Lower Middle | 8 | 25.81 | 25.81 | 41.94 |
| | Middle | 10 | 32.26 | 32.26 | 74.19 |
| | Upper Middle | 8 | 25.81 | 25.81 | 100.00 |
| **Marital Status** | | | | | |
| | Valid | 1 | 3.23 | 3.23 | 3.23 |
| | Married | 22 | 70.97 | 70.97 | 74.19 |
| | Unmarried | 6 | 19.35 | 19.35 | 93.55 |
| | Divorcee | 2 | 6.45 | 6.45 | 100.00 |
| **Occupation** | | | | | |
| | Valid | 1 | 3.23 | 3.23 | 3.23 |
| | Unemployed | 3 | 9.68 | 9.68 | 12.90 |
| | Private Job | 14 | 45.16 | 45.16 | 58.06 |
| | Govt Job | 6 | 19.35 | 19.35 | 77.42 |
| | Labor | 2 | 6.45 | 6.45 | 83.87 |
| | Farmer | 5 | 16.13 | 16.13 | 100.00 |

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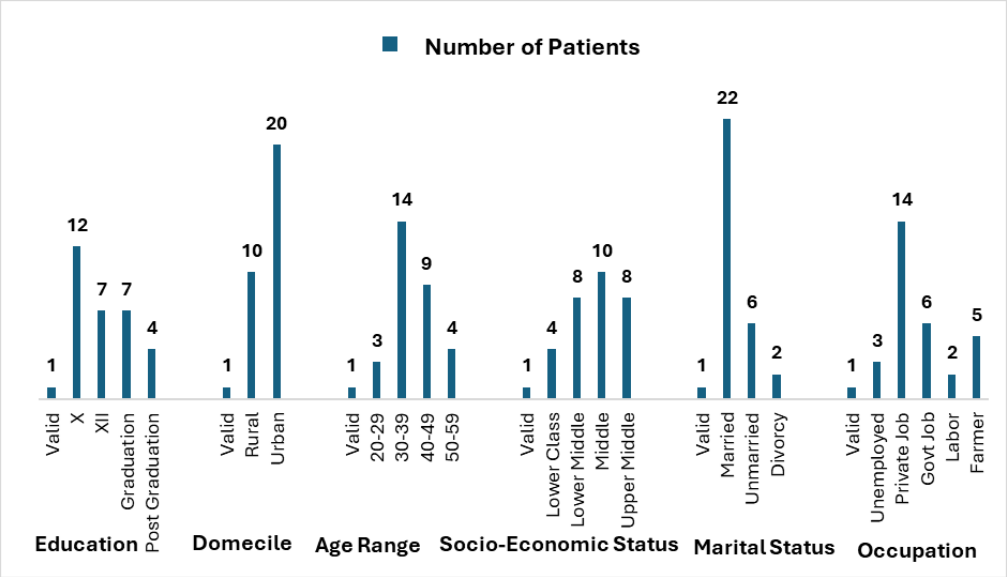


**Figure 1** Demographic Details of the Patients (n= 30)

### 3.2. Neuropsychological Test Performance

The details of the results for all 9 neuropsychological tests comparing both the BPAD and BPAD+ADS groups are presented in the Table 3. Statistical analysis showed no significant differences between groups (at $p > 0.05$), however evaluation of descriptive statistics and effect sizes revealed significance clinical pattern (Figure 2).

**Table 3** Comparative details for the Neuropsychological Test Performance between BPAD and BPAD+ADS groups

| Test | BPAD (n=17) | | BPAD+ADS (n=13) | | t-value | Cohen's d |
|---|---|---|---|---|---|---|
| | M | SD | M | SD | | |
| PGI-Memory Scale | 58.06 | 3.05 | 58.31 | 2.9 | 0.62 | 0.027 |
| Token Test | 32.18 | 1.98 | 31.62 | 2.99 | 0.019 | 0.228 |
| Digit Vigilance | 31.9 | 2.57 | 31.9 | 2.56 | 1.25 | 0 |
| Logical Memory | 10.88 | 1.38 | 9.77 | 1.05 | 0.213 | 0.364 |
| WCST | 71.06 | 2.76 | 71.75 | 3.25 | 0.929 | 0.078 |
| AVLT | 24.25 | 1.69 | 20.54 | 1.62 | 0.301 | 0.391 |
| Digit Substitution | 16.82 | 1.43 | 19.15 | 1.04 | 0.422 | 0.184 |
| Verbal Working Memory | 10.35 | 1.41 | 11 | 1.35 | 0.302 | 0.281 |
| Trails Test | 8.06 | 1.22 | 8.31 | 1.8 | 0.992 | 0.061 |

M = Mean; SD = Standard Deviation; BPAD = Bipolar Affective Disorder; BPAD+ADS = Bipolar Affective Disorder with Alcohol Dependence Syndrome; WCST = Wisconsin Card Sorting Test; AVLT = Auditory Verbal Learning Test. None of the comparisons reached statistical significance at $p < .05$.

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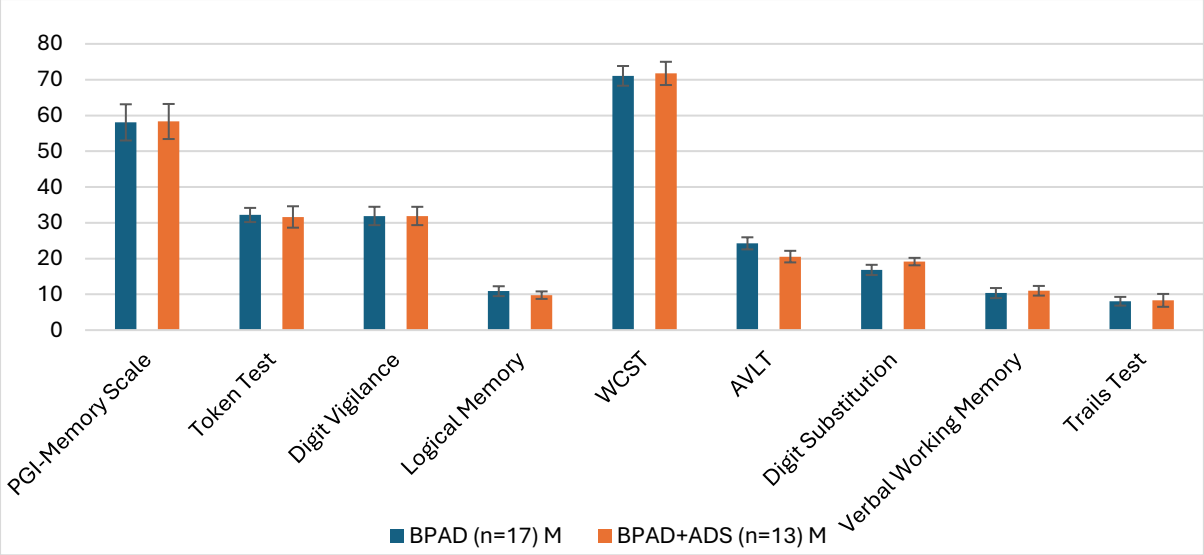


**Figure 2** Mean performance scores for BPAD and BPAD+ADS groups across all nine neuropsychological measures. Error bars represent standard deviations.

### 3.3. Domain-Specific Analysis

#### 3.3.1. Memory Function

The PGI memory scale (Pershad & Wig, 1977) accesses multiple memory dimensions viz. remote, recent, and immediate memory, as well as concentration, attention, mental balance, recognition and retention. On the PGI-Memory scale, both the trial groups showed almost similar performance (Table 3, Figure 2). Assessment of immediate and delayed recall of narrations conducted by logical memory test, revealed a descriptive trend. The effect size of d = 0.364 approaches the threshold for a medium effect, suggesting that patients with comorbid alcohol dependence may experience high difficulty with immediate and delayed recall of contextually (Table 3, Figure 2).

Auditory Verbal Learning Test (AVLT), (Schmidt, 1996) measures verbal-learning through multiple trials and evaluates the learning efficiency and memory consolidation. The AVLT test showed the largest numerical difference between groups (Table 3, Figure 2).

#### 3.3.2. Executive Function

Evaluation of executive function was performed by Wisconsin Card Sorting Test (WCST) (Riccio et al., 1994) which revealed no significant difference between groups. This finding was unexpected given the previous reports of executive dysfunction in alcohol dependence (Table 3, Figure 2).

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### 3.3.3. Attention and Processing Speed

Digit Vigilance Test (Yang et al., 2015) showed the results related to sustained attention and vigilance, which were similar in both the trial groups and the Trails Test, evaluating visual and divided attention and processing speed also showed minimal differences between the groups (Table 3, Figure 2). The psychomotor speed and sustained attention tests were measured by the digit substitution test (Kalra et al., 1993) revealed a small numerical advantage for the BPAD+ADS group as compared to the BPAD group ($t = 0.422$, $p > .05$, $d = 0.184$). This unexpected direction of effect suggests that processing speed was not differentially impaired in the comorbid group (Table 3, Figure 2).

### 3.3.4. Language and Working Memory

The auditory comprehension and abilities of receptive language, were evaluated by token test (Renzi 1962), showed a small numerical difference favoring the BPAD group, whereas working memory capacity for verbal information revealed differences between groups.

### 3.4. Effect Size Analysis

Figure 3 presents the t-values for all neuropsychological tests, and Figure 4 displays the effect sizes (Cohen's d) for all comparisons, providing insight into the magnitude of group differences independent of sample size considerations. The largest effect sizes were observed for AVLT ($d = 0.391$) and Logical Memory ($d = 0.364$), both in the small-to-medium range, suggesting significant additive cognitive burden in memory domains associated with comorbid alcohol dependence.

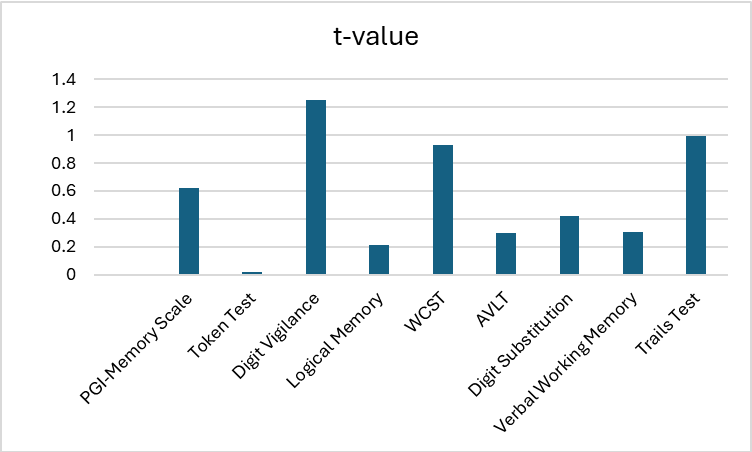


**Figure 3** T-values for independent samples comparing BPAD and BPAD+ADS groups across all neuropsychological measures

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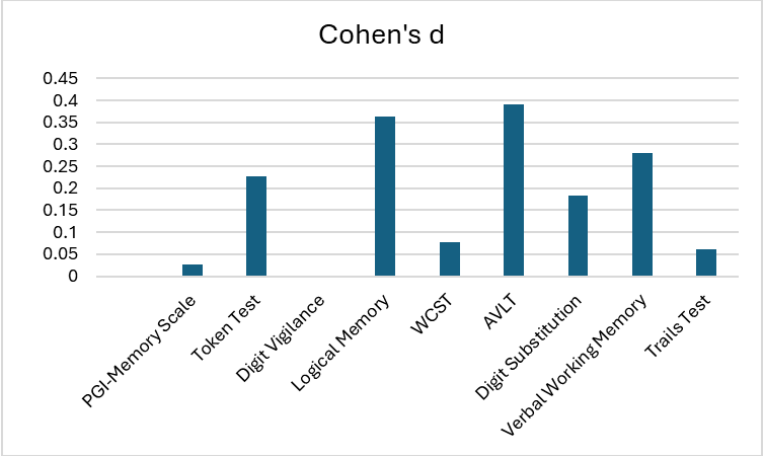


**Figure 4** Effect sizes (Cohen's d) for all neuropsychological comparisons.

Figure 5 presents a heatmap visualization of the comparative performance patterns across all tests. Color intensity represents relative performance levels, explaining the overall pattern of similarities with subtle variations in memory-related measures. Better performance indicated by higher scores is shown in green, while poor performance indicated by lower scores is shown in red. Lower scores were observed in the Logical Memory and Trails Test, indicating comparatively poor performance in these domains, both groups exhibit relatively higher scores on the WCST, suggesting better executive functioning performance.

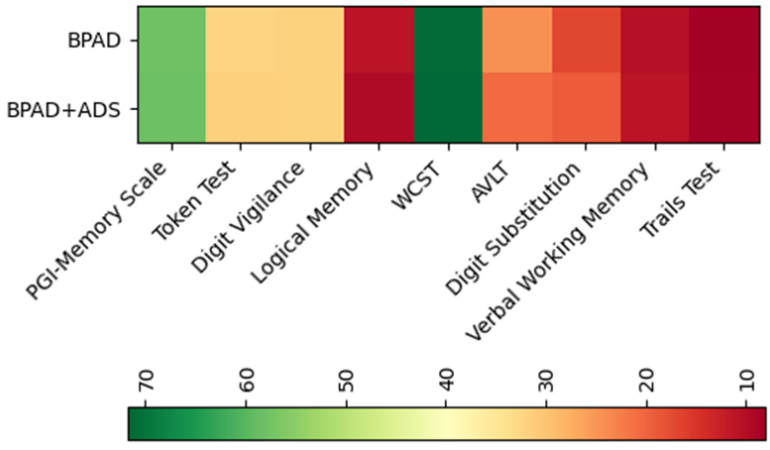


**Figure 5** Heatmap of mean performance scores across all neuropsychological tests for BPAD and BPAD+ADS test groups.

## 4. Discussion

The present investigation evaluated various neuropsychological attributes across different cognitive domains in patients with BPAD and with BPAD comorbid with ADS. Contrary to the primary hypothesis, there was no significant difference observed between the two test groups across all the 9 neuropsychological tests. However, effect

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size and descriptive trends estimate revealed some potentially meaningful differences, particularly in verbal memory and learning which can further be evaluated at a larger sample size.

Performance test on the PGI Memory Scale showed similar results across groups, which revealed that global memory functioning may be equally affected in BPAD patients despite of alcohol comorbidity. The aggregation of multiple domains in the PGI memory scale which limits the sensitivity of domain specific deficits. Further Clinical variables e.g., duration of illness, number of mood episodes and effect of medication may contribute to the restricted variability in performance (Gupta, 2016; Kumar et al., 2025; Walia et al., 2023).

In contrast, tests evaluating verbal memory and learning showed the highest effect sizes. On the AVLT, a small-to-medium effect size (d = 0.391) was observed showing the worst performance of the BPAD+ADS group. Similarly, the Logical Memory test showed a small-to-medium effect (d = 0.364), favoring the BPAD-only group.

These findings correspond to the previously reported studies showing the verbal memory deficits in bipolar disorder as well as alcohol dependence (Boumis, 2022; Cardoso et al., 2016; Sumiyoshi et al., 2017). BPAD has constantly been associated with deficits or impairments in verbal learning, immediate recall and encoding even during the stable states of the patients (Deckersbach et al., 2004; Robinson et al., 2006). Further, the alcohol dependence, independently, is linked to deficits in memory consolidation and retrieval, particularly involving hippocampal and medial temporal lobe structures (Molnár et al., 2011).

Efficiency of encoding and memory consolidation across the test groups was evaluated by a sensitive AVL test. The results showing poorer performance in the comorbid group reflected aggregated effects of repeated mood episodes combined with chronic exposure to alcohol (Villa et al., 2024). Similarly, the results observed from Logical Memory test were statistically non-significant suggest however, the moderate magnitude of effect size (d = 0.364) shows clinically significant trend that that alcohol dependence can aggravate the encoding incompetence already present in BPAD (Kumar et al., 2025; Swapna, 2008).

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Executive functioning, assessed using the WCST, showed no significant differences between groups (d = 0.078) which was contrary to the previous reports of executive dysfunction in both BAPD and BPAD + ADS (Nehra et al., 2006; Raipure, 2021). Several factors may be behind this result including substantial presence of executive dysfunction present in BPAD patients which limits the detectable impact of alcohol dependence (Maharjan et al., 2022; van Gorp et al., 1998). Further, the WCST describes specific aspects of executive function such as cognitive flexibility and set-shifting and fails to detect deficits in planning and verbal fluency, which can be more sensitive to alcohol-related impairment. Additionally, the duration of self-restraint or cognitive recovery can also occur with sustained abstinence from alcohol (Miles et al., 2021). If participants in the BPAD+ADS group had achieved a period of sobriety prior to assessment, this may have attenuated group differences.

The results of evaluation of processing speed and attention was done through Digit Vigilance Test, Trails Test, and Digit Substitution Test revealed very less differences between groups being the effect sizes ranging from 0.0 - 0.184 and the psychomotor speed, sustained attention and visual attention or scanning affected significantly across both groups. Performance score for digit vigilance test was almost similar which is significant because the deficits of attentional encoding are major factor of bipolar disorder and reduced sustained attention is more common in ADS. The similarity of the results shows overlapping of impairment across groups or limited sensitivity of the test (Camelo et al., 2017; Clark et al., 2002; Maalouf et al., 2010). Further, the performance on the trails test indicated similar visual attention and ability of set-shifting followed by the better performance score in the BPAD + ADS group in the digit substitution test. The paradox in the results can be due to reflect sample variability or some unaccounted demographic differences (Jaeger, 2018). Overall, attention and processing speed domains did not demonstrate a definite additive impairment associated with alcohol comorbidity.

The verbal working memory test (d = 0.281) indicated that the performance score of BPAD+ADS group was better contradicts the earlier research which reported pronounced working memory deficits in BPAD + ADS (Kumar et al., 2025; Robinson, 2020). It is possible that the BPAD group participated in the present investigation had particularly high working memory impairment with respect to the characteristics of illness.

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Numerous studies indicate a correlation between bipolar disorder and enduring neurocognitive deficits, especially in verbal memory and executive function, even during remission. Additionally, dependence on alcohol independently contributes to cognitive impairment across memory, executive control, and psychomotor speed (Keramatian et al., 2021; Martinez-Aran et al., 2007). Studies comparing bipolar patients with and without alcohol dependence generally report greater deficits in the comorbid group, particularly in verbal learning and recall. During remission, individuals with recent alcohol dependence often show smaller cognitive gains over time (Cardoso et al., 2016; Chang et al., 2012; Martínez-Arán et al., 2000; van Gorp et al., 1998; Zhang et al., 2020). The present study partially aligns with this literature. Trends indicating reduced performance in verbal memory and learning within the BPAD+ADS group align with increased cognitive burden. Nonetheless, the lack of significant differences in executive and attentional domains differ from some prior findings. Differences in sample size, clinical heterogeneity, abstinence duration, medication status, and statistical power likely contributed to these discrepancies (M. Day et al., 2015; Stephan et al., 2017).

## 5. Conclusion

The present research investigated neuropsychological functioning among multiple cognitive domains in patients with bipolar affective disorder (BPAD) and patients with BPAD comorbid with alcohol dependence syndrome (BPAD+ADS). Statistical analysis revealed no significant differences between groups on any of the 9 neuropsychological measures. However, examination of descriptive patterns and effect sizes suggests potential clinically significant trends, particularly in memory and learning domains.

The Auditory Verbal Learning Test (d = 0.391) and Logical Memory test (d = 0.364) had the largest effect sizes which suggests that persons with comorbid alcohol dependence may have more cognitive burden in verbal memory and learning areas.

In contrast, executive function as measured by the WCST, attention and processing speed measures, and working memory showed very little differences between groups, with effect sizes ranging from 0.0 - 0.281 suggesting that these cognitive domains may be affected in both groups comparatively.

https://doi.org/10.71058/jodac.v10i06006

The observed results in memory and learning domains may show actual cognitive differences that would emerge with adequate statistical power. Additionally, clinical heterogeneity, lack of systematic control for mood state and medication effects, and the cross-sectional design limit the conclusions that can be drawn.

Despite these limitations, the study makes several important conclusions including a detailed comparative neuropsychological data on patients with BPAD and comorbid ADS using a comprehensive assessment test series. The findings emphasize the significance of domain specific cognitive assessment in dual-diagnosis populations. The results show that clinical practices the psychiatrists must include full set of neuropsychological evaluations alongwith integration of treatment including drugs into bipolar disorder management.

For patients with comorbid alcohol dependence, the potential for additive cognitive burden as shown by the effect sizes in memory domains indicates the importance of rigorous treatment for substance use disorders and monitoring for cognitive impairments that may hinder treatment adherence and functional recovery. To draw conclusive and reproducible results future research with larger sample sizes and more comprehensive clinical characterization is required. Integration with neuroimaging and biomarker assessments is also required to characterize the cognitive consequences of comorbid BPAD and ADS.

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