INTRODUCTION

Neurocognitive theories have proposed that substance use disorders are characterized by self-regulatory failure. Two systems play a crucial role in self-regulation (i) reflective/executive system, which is generally associated...
with the prefrontal cortex (PFC) and impulsive/reactive system generally associated with the limbic system. A suboptimal balance between these two systems (i.e., heightened impulsiveness/overvalued rewarding effect and poor executive control that generally controls impulsive responding) plays a crucial role in substance use disorders.\(^1\)\(^{13}\)

The impulsive system works on the immediate gratification of pleasurable impulses, seeking rewards without consideration of consequences, exaggerating the rewarding impact of available incentives. The reflective system/executive system works on the attainment of adaptive goal pursuit and inhibits prepotent responses or impulses for achieving goals successfully. Individuals with substance use disorders demonstrate dysfunctions in self-regulatory processes that may result from impairment in one or both systems. For example, individuals with weak (hypofunction or dysfunction) higher-order cognitive processes may be unable to weigh the negative consequences of substance abuse, unable to learn from mistakes, oblivious to their decisions, and thus, they continue to use substances despite accruing harm. Similarly, substance use disorders could be the result of hyperactivation of the brain-reward system that produces reward learning deficits\(^4\) that lead to compulsive use to seek immediate gratification (i.e., rewarding effect from substance use). Moreover, heightened impulsivity may lead to impulsive responses toward the immediate reward/pleasurable effect of substance abuse despite negative consequences in the longer term.\(^1\)

Hence, substance use disorders could be the result of disadvantageous reward processing/risk-taking (i.e., impulsive responding towards the stimuli that have high immediate rewards but disadvantageous in long-term over advantageous behaviours that have low immediate reward but incur profit in long term). This behavioral tendency can be assessed through gambling simulation tasks such as the Iowa gambling task (IGT). The IGT assesses decision making involving risk and uncertainty in terms of unknown reward and penalty probability.\(^5\) Advantageous decks selection on IGT reflects one aspect of good executive functions/self-control,\(^6\) while poor performance reflects dysfunction of the frontal and/or limbic cortex.\(^5\)\(^,\)\(^7\)

Similarly, impulsivity is one of the core features of substance use disorders, including alcoholism.\(^8\)\(^\text{-}^\text{10}\) Impulsivity can be associated with different stages of alcoholism, such as its initiation and course.\(^11\) Persons with impulsive characteristics take decisions or responses without proper consideration of possible options and consequences. Impulsivity and its different dimensions, such as nonplanning, attentional, and motor impulsivity, were independently predictive of alcohol consumption.\(^12\)\(^\text{-}^\text{13}\)

Neurocognitive theories of substance use disorders provide newer strategies for the treatment of substance dependence, including alcoholism. However, to date, there is a dearth of behavioral interventions that aim to promote self-regulation in individuals with substance use disorders. We developed an Integrated Intervention Program for Alcoholism (IIPA) principally based on neurocognitive theories of addiction. The IIPA has two components (i) Cognitive remediation program and (ii) Mind-Body exercise (Qigong and Tai Chi Chuan). The cognitive remediation program intends to ameliorate cognitive/executive deficits or enhance executive functioning (for example, working memory, inhibitory control, and mental flexibility) and thus improving executive/self-control (prefrontal/top-down control).\(^14\) Several studies have proven the effectiveness of cognitive remediation programs in improving executive functions in persons with substance use disorders, including alcoholism.\(^15\)\(^\text{-}^\text{17}\) Similarly, it is hypothesized that the relief of negative affect and stress plays an important role in substance use disorders.\(^18\)\(^\text{-}^\text{20}\) The dysregulation of reward circuits, including hormonal (hypothalamic-pituitary-adrenal axis) and stress system, plays a crucial role in the initiation of long-term compulsive use of substances.\(^21\)\(^,\)\(^22\) The mind-body exercise (Qigong and Tai Chi Chuan) is known to be effective in reducing stress, salivary cortisol, and enhances relaxation.\(^23\)\(^\text{-}^\text{25}\)

The present study was aimed to examine the effects of the IIPA on impulsiveness and disadvantageous reward processing/risk-taking (i.e., impulsive responding to the decks that have high immediate rewards but disadvantageous in long term over advantageous decks that have low immediate reward but incur profit in long term) in persons with alcoholism.

**MATERIALS AND METHODS**

The sample comprised 50 individuals diagnosed with alcohol dependence as per the International Classification of Disease-10 research diagnostic criteria. Participants were allotted into two groups by the randomly matched method. They were matched on age and education (±1 year). Selection criteria were early-onset (before 25 years of age) alcohol dependence and positive family history of alcohol dependence (one or more first-degree family members with alcoholism). Participants were recruited from the inpatient setting of Centre for Addiction Medicine, NIMHANS, Bengaluru. The exclusion criteria for the study were, presence of other substance use disorders (except tobacco) such as cannabis; any major Axis I psychiatric disorders in participants and/or first-degree family members such as schizophrenia and mood disorders; self-reported major co-morbid medical or neurological disorders; severe memory impairment as assessed on Hindi Mental State Examination (less than 24 scores) and those who have received structured therapy, meditation practices or cognitive retraining in the past 1 year.

Written informed consent was sought from each participant, and there was no monetary benefit for participation. The
study followed the declaration of Helsinki provisions, and ethics clearance was sought from the Institute’s ethics committee (Ref: NIMH/DO/SUB-COMMITTEE/2013). This study was registered with Clinical Trial Registry-India (Ref: CTRI/2017/08/009346).

Tools
*Demographic-clinical datasheet and screening measures*
Details regarding sociodemographic variables such as age, education, socioeconomic status, and information related to alcoholism such as the age of alcohol initiation, age of alcohol dependence, duration of alcohol use, duration of alcohol dependence, etc., were recorded on a Demographic-Clinical data sheet prepared for the present study. Screening of major psychiatry disorders such as schizophrenia and mood disorders in participants and first-degree family members were ruled out through Mini-International Neuropsychiatric Interview-Version 6.0 (University of South Florida, TAMPA, USA). Family Interview for Genetic Studies was used to document information related to alcoholism in first-degree family members. The Hindi Mental State Examination was administered to screen severe memory impairment (less than 24 scores) in participants. The current severity of alcoholism was assessed on the Short Alcohol Dependence Data Questionnaire. The Semi-Structured Assessment for Genetics of Alcoholism-version II was administered to assess score externalizing disorders.

Outcome measures
*Barratt’s Impulsiveness Scale-Version-11*
Barratt’s Impulsiveness Scale (BIS) is a self-report instrument designed to assess the personality/behavioral construct of impulsiveness. It assesses various domains or multi-factors of general impulsiveness through six first-order factors and three second-order factors.

*Modified Iowa gambling task*
A software version of IGT was prepared based on original IGT used by Bechara et al. We kept the frequency of reward/punishment schedule more explicit and to increase the penalty sensitivity. Thus, modified IGT (mIGT) has a more explicit contrast between delayed gain and loss and increases the subject’s sensitivity to the embedded rule of each deck.

The task has four decks A, B, C, and D. Selecting any card from deck A or deck B yield 100 rupees and selecting any card from deck C or deck D yield 50 rupees. Decks A and B are disadvantageous decks as they have high penalties and cost in the long run (delayed loss). Deck A produces the highest loss in the long run. Deck C and D have low penalties, and they considered to be “advantageous decks” because they produce gains or no loss in the long run.

Procedure
Socio-demographic and screening tools, and outcome measures were administered to both groups at baseline (i.e., after the detoxification of 3–4 days). After the baseline assessment, the treatment as usual (TAU) group received pharmacotherapy, yoga (6 sessions in a week) and group therapy on relapse prevention (three sessions in a week) for 18 days while the intervention group received the IIPA intervention for 18 consecutive days along with usual treatment. The IIPA has two components (i) Cognitive remediation program intends to improve executive functioning such as attention, working memory, mental flexibility, and inhibitory control (ii) mind-body exercises (Qigong and Tai Chi Chuan) intend to enhance affect regulation, reduce stress and enhance relaxation. More details of IIPA can be seen in Kumar et al. Outcome assessment was repeated following the 18 days of intervention in both the groups.

Statistical analysis
Statistical analysis was carried out using the Statistical Package for the Social Sciences-version 22 (IBM-SPSS-v22, Armonk, NY: IBM Corp) for Windows. The normality of data was examined using the Shapiro-Wilk test and found that data were normally distributed. Sample characteristics were described by descriptive statistics (mean, standard deviation, frequency, and percentage). An independent sample t-test was used for comparison at baseline for continuous variables. Repeated measure analysis of variance was applied to examine the differences from pre-intervention (baseline) to post (post-intervention) for all the outcome measures. Pre to post-intervention difference within the group was also reported by pairwise comparison. Effect size in both groups was described using partial eta squared ($\eta^2$), which showed the size or magnitude of change from pre- to post-intervention in both the groups.

RESULTS
Comparison between the two groups on Sociodemographic and clinical characteristic
Participants in both the groups were in the age range of 18–45 years, the average mean was 34.28 ± 5.33 (standard deviation [SD]) in the IIPA group and 34.08 ± 5.73 (SD) in the TAU group. The average year of education was 11.08 ± 2.48 (SD) in the IIPA group and 11.12 ± 2.45 (SD) in the TAU group. The majority of participants belonged to middle socioeconomic status (56% in the IIPA group and 44% in the TAU group) and lower socioeconomic status (36% in the IIPA group and 44% in the TAU group). There was no significant difference between the groups in terms of socioeconomic status ($\chi^2 = 0.76; p = 0.68$). Both the groups were also comparable in terms of onset of alcohol use ($P = 0.456; 18.64 \pm 2.53$ [mean ± SD; IIPA group], 19.24 ± 3.09 [mean ± SD; TAU group]), age of alcohol dependence ($P = 0.662; 23.64 \pm 2.61$ [mean ± SD; IIPA group], 23.96 ± 2.68 [mean ± SD; TAU group]),...


Comparison between the two groups on outcome measures

Impulsiveness

Impulsivity was assessed by the BIS-11. As shown in Table 1, there was no significant difference between the two groups on the total score of impulsivity at baseline. However, the sub-components of impulsivity analysis revealed that the intervention (IIPA) group had more impulsivity scores on cognitive complexity and nonplanning impulsiveness. Postintervention result [Table 2] showed that there was a significant difference between the two groups on the total score of impulsivity and its subcomponents (i.e., attention, motor, self-control, cognitive complexity, perseverance, cognitive instability, attentional impulsiveness, motor impulsiveness, and nonplanning impulsiveness). The IIPA group had a significant reduction in impulsivity scores [Table 2]. Furthermore, the effect size was larger in the IIPA group.

Disadvantageous reward processing/risk-taking on decision-making task

Table 3 indicates that there was no significant difference between both groups on the decision making task (mIGT), which assesses disadvantageous reward processing/risk-taking (impulsive responding towards immediate reward without consideration of long term outcome and/or low sensitivity to negative consequences). Hence, both groups were comparable at baseline.

However, post-intervention results [Table 4] showed a significant change on the decision making task in the intervention (IIPA) group compared to the TAU group. The IIPA group had a significant reduction in selection from the disadvantageous decks (i.e., A and B), and increase selection from advantageous decks (i.e., C and D). There was also a significant change in the IIPA group for total disadvantageous selections (i.e., A + B) and advantageous selections (i.e., C + D) as well as for net score (i.e., advantageous selections-disadvantageous selections). The effect size was found to be larger.

DISCUSSION

Alcoholism is associated with reward deficiency, and studies have demonstrated disruption in brain structures associated with reward processing. Similarily, on decision-making tasks that simulate real-life decision-making process, individuals with substance use disorders demonstrate poor decision-making performance. Furthermore, studies have consistently demonstrated an association between impulsivity and alcohol use in adults. Impulsivity is one of the important predictors of substance abuse and related problems, whether it is assessed by self-report or behavioral and neuropsychological tests. Impulsivity is not a unitary construct, and can be defined in several ways such as a diminished capacity to focus on tasks at hand (i.e., attentional impulsiveness) and/or persist or persevere in tasks (i.e., motor impulsiveness); a tendency to act on the spur of the moment and poor future planning (i.e., nonplanning impulsiveness).

The present study assessed impulsivity using self-reported measures (Barratt’s Impulsiveness Scale) as well as a behavioral task (the IGT) that assesses decision making and disadvantageous reward processing/risk-taking. Impulsiveness on IGT is reflected in terms of impulsive responding towards the decks that have high immediate rewards but disadvantageous in long-term (delayed loss)
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Table 2: Pre-post intervention comparison of the two groups on impulsivity and sub-components of impulsivity

| Variables                        | Mean±SD                  | Time (T) | Group (G)          | Within group pre to post (P, η²) |
|----------------------------------|--------------------------|----------|--------------------|----------------------------------|
|                                  | IIPA group (n=25)        | TAU group (n=25) | F, P                | F, P                | η²                | F, P                | η²                |
| BIS total                        |                          |           |                    |                    |                   |                    |                   |
| Pre                              | 77.09±8.30               | 72.50±8.60| 49.12, 0.61        | 29.26, 0.001***   | 0.001***, 0.65 (L) | 0.265, 0.03       |
| Post                             | 61.91±11.36              | 70.55±9.35| 0.001***           | 0.001***           |                    |                    |
| BIS attention                    |                          |           |                    |                    |                   |                    |                   |
| Pre                              | 11.50±2.35               | 10.82±2.13| 25.74, 1.56        | 21.45, 0.001***   | 0.001***, 0.53 (L) | 0.757, 0.01       |
| Post                             | 8.50±2.26                | 10.68±2.21| 0.001***           | 0.001***           |                    |                    |
| BIS motor                        |                          |           |                    |                    |                   |                    |                   |
| Pre                              | 18.55±3.66               | 17.68±3.72| 11.23, 0.08        | 5.19, 0.002**     | 0.001***, 0.27 (L) | 0.452, 0.01       |
| Post                             | 15.68±3.18               | 17.14±4.77| 0.002**            | 0.028*            |                    |                    |
| BIS self-control                 |                          |           |                    |                    |                   |                    |                   |
| Pre                              | 16.18±2.70               | 14.41±4.12| 33.71, 0.28        | 10.40, 0.001***   | 0.001***, 0.49 (L) | 0.075, 0.07       |
| Post                             | 12.64±3.12               | 13.41±3.96| 0.001***           | 0.002**           | 0.600             |                    |
| BIS cognitive complexity         |                          |           |                    |                    |                   |                    |                   |
| Pre                              | 15.68±2.61               | 13.59±2.42| 9.03, 0.01         | 21.90, 0.001***   | 0.001***, 0.41 (L) | 0.243, 0.03       |
| Post                             | 12.14±2.51               | 14.36±2.40| 0.004**            | 0.001***           |                    |                    |
| BIS perseverence                 |                          |           |                    |                    |                   |                    |                   |
| Pre                              | 8.41±2.72                | 8.91±2.41 | 2.97, 0.09         | 0.63, 0.043       | 0.082, 0.07       | 0.515, 0.01       |
| Post                             | 7.55±2.52                | 8.59±1.59 |                    |                   |                    |                    |
| BIS cognitive instability        |                          |           |                    |                    |                   |                    |                   |
| Pre                              | 6.77±2.43                | 7.09±2.60 | 14.68, 0.85        | 1.50, 0.0228      | 0.001***, 0.23 (L) | 0.072, 0.08       |
| Post                             | 5.36±2.72                | 6.36±2.40 | 0.001***           |                   |                    |                    |
| BIS attentional impulsiveness    |                          |           |                    |                    |                   |                    |                   |
| Pre                              | 18.27±3.67               | 17.91±3.53| 33.11, 1.96        | 14.97, 0.001***   | 0.001***, 0.52 (L) | 0.190, 0.04       |
| Post                             | 13.86±4.17               | 17.05±3.26| 0.001***           | 0.001***           |                    |                    |
| BIS motor impulsiveness          |                          |           |                    |                    |                   |                    |                   |
| Pre                              | 26.95±5.04               | 26.59±4.25| 14.09, 0.72        | 5.48, 0.001***    | 0.001***, 0.31 (L) | 0.324, 0.02       |
| Post                             | 23.23±4.68               | 25.73±4.53| 0.001***           | 0.024*            |                    |                    |
| BIS nonplanning impulsiveness    |                          |           |                    |                    |                   |                    |                   |
| Pre                              | 31.86±4.30               | 28.00±5.48| 28.13, 0.11        | 24.72, 0.001***   | 0.001***, 0.56 (L) | 0.816, 0.01       |
| Post                             | 24.82±4.67               | 27.77±5.71| 0.001***           | 0.001***           |                    |                    |

*p<0.05, **p<0.01, ***p<0.001. L – Large effect size; BIS – Barratt’s Impulsiveness Scale; SD – Standard deviation; IIPA – Integrated intervention program for alcoholism; TAU – Treatment as usual

Table 3: Reward processing and decision-making on Iowa gambling task in both groups at baseline

| Variables            | Mean±SD                  | t      | P      |
|----------------------|--------------------------|--------|--------|
|                      | IIPA group (n=25)        | TAU group (n=25) |        |
| IGT A                | 23.18±7.26               | 21.64±9.55 | 0.60  |
| IGT B                | 31.95±6.85               | 32.41±6.04 | -0.23 |
| IGT C                | 18.82±6.03               | 21.27±7.43 | -1.20 |
| IGT D                | 26.14±8.33               | 24.68±8.085 | 0.59  |
| IGT risk             | 55.14±10.11              | 54.05±12.47 | 0.32  |
| IGT safe             | 44.95±10.04              | 45.95±12.47 | -0.29 |
| IGT net score        | -10.18±20.14             | -8.09±24.93 | -0.31 |

Net score – Safe selections-risky selections. IGT – Iowa gambling task; SD – Standard deviation; IIPA – Integrated intervention program for alcoholism; TAU – Treatment as usual

over advantageous decks that have low immediate rewards but incur profit in long-term.

Poor performance on the IGT can result from impulsive responding or acting impulsively (motor impulsivity) towards the immediate reward, predominantly focusing on immediate reward than on future consequences or reduced response for long-term negative consequences (non-planning impulsiveness) and difficulty in concentrating (attention component of impulsivity).[44,45] A similar behavioral tendency can be observed in persons with substance use disorders who prefer the consumption of substances (immediate gratification) over long term harmful consequences to health, employment, and family.[46,47] On the other hand, executive functions play a crucial role in cognitive control, such as processing of reward, emotion, and decision-making.[48] Impulsivity is also defined as “Disinhibition.”[49] Disinhibition refers to the dysfunction of the “Top-Down” control mechanism required in cognitive control over unwanted stimuli and responses in the face of current demands.[50] Hence, impulsivity increases in individuals with alcoholism due to dysfunction of the top-down control mechanism required for suppressing the unwanted thoughts, emotion, and action related to alcohol abuse.[51,52] Impulsivity can be a determinant for alcoholism as well as a consequence acquired from the alcoholism. In both ways, it increases the use of alcohol and prevents abstinence.[52,53] Persons with alcoholism demonstrate high impulsiveness and disadvantageous selections on decision-making tasks.[54] Studies have reported that impulsivity may vary in relation to dynamic affective processes. In other words, affective processes influence impulsive behaviors such as nonplanning tendency (negative urgency) under the influence of negative affective states.[55,56] Furthermore,
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| Variables                          | Mean±SD IIPA group (n=25) | TAU group (n=25) | T (F, P) | Group (G, F, P) | T × G (F, P) | Within group pre to post (P, n²) |
|-----------------------------------|---------------------------|------------------|----------|----------------|-------------|---------------------------------|
| IGT deck A                        | 23.18±7.26                | 21.63±9.55       | 15.79    | 0.52           | 2.79        | 0.001***, 0.28 (L)              |
| TAU group                         |                           |                  |          |                |             |                                 |
| IGT deck B                        | 31.95±6.85                | 32.41±6.04       | 2.89     | 6.80           | 3.64        | 0.005**, 0.18 (L)               |
| IITA group                        |                           |                  |          |                |             |                                 |
| IGT deck C                        | 18.82±6.03                | 21.27±7.43       | 10.94    | 1.03           | 6.48        | 0.001***, 0.29 (L)              |
| TAU group                         |                           |                  |          |                |             |                                 |
| IGT deck D                        | 26.14±8.33                | 24.68±8.09       | 6.13     | 4.03           | 2.12        | 0.008**, 0.16 (L)               |
| IITA group                        |                           |                  |          |                |             |                                 |
| IGT risky selections (A + B)      | 55.14±10.11               | 54.05±12.47      | 14.68    | 3.62           | 7.12        | 0.001***, 0.34 (L)              |
| TAU group                         |                           |                  |          |                |             |                                 |
| IGT safe selections (C + D)       | 44.95±10.04               | 45.95±12.46      | 14.68    | 3.67           | 7.09        | 0.001***, 0.33 (L)              |
| TAU group                         |                           |                  |          |                |             |                                 |
| IGT net score (safe-risky)        | −10.18±2.14               | −8.09±24.93      | 14.68    | 3.64           | 7.11        | 0.001***, 0.33 (L)              |
| TAU group                         |                           |                  |          |                |             |                                 |
| IITA group                        | 21.73±31.03               | −2.36±23.07      | 0.001*** | 0.063          | 0.011**     |                                 |

*P<0.05; **P<0.01; ***P<0.001. L – Large effect size; SD – Standard deviation; IIPA – Integrated intervention program for alcoholism; TAU – Treatment as usual; IGT – Iowa gambling task

this may be linked with substance use behavior at different stages (i.e., initiation, maintenance, or relapse). It is found that higher negative urgency was significantly associated with higher levels of negative reinforcement-driven drinking behaviors (i.e., drinking to cope). Similarly, positive affective states may also increase impulsive behavior or act rashly and quantify substance-related problems.

Our results showed that IIPA that intends to improve executive functioning and affect regulation led to a significant reduction in impulsivity and disadvantageous reward processing/risk-taking. Executive functions generally associated with the PFC play a major role in addiction through the regulation of limbic reward regions. The PFC generally exerts “Top-Down” inhibitory control over internal and external -driven compulsive behavior. Studies have suggested that continuous long-term use of substances, including alcohol, attenuates the PFC ability to monitor and inhibit addictive behaviors. Hence, an individual loses the ability for self-control. Both the attenuation of the executive control and enhancement of impulsive networks are closely related to alcoholism. Therefore, we assume that regaining capacities of the executive functions through IIPA may have enhanced the executive control/self-regulation. The enhanced executive control could mediate the neural networks involve in impulsive and disinhibited behavior. This is reflected by the differential improvements in impulsivity/impulsive responding and disadvantageous decision making in the IIPA group.

CONCLUSION

Impulsivity and disadvantageous decision-making/risk-taking are the core features of substance use disorders/addictive disorders. Both are closely related and predict hazardous behaviors such as substance abuse. Persons with alcohol dependence relapse early if their performance is governed by impulsive responding or immediate rewards. Hence, it can be presumed that improvement in impulsivity and disadvantageous reward processing/risk-taking in persons with alcoholism may lead to better treatment outcomes such as reducing relapse rates and maintaining sobriety. This study has some limitations. It was a pilot study to test the effects of an integrated intervention program (i.e., IIPA) on impulsivity and disadvantageous reward processing/risk-taking from pre- to post-intervention. Further studies may examine improving these characteristics with IIPA and its impact on the treatment outcome of substance use disorders/addictive disorders. The sample size of 50 participants (25 in each group) is a small sample size. Future studies may use a large sample size to increase its generalizability. This study lacks follow-up assessments. Despite the present study limitation, these variables may be of interest in the treatment of substance use disorders/addictive disorders.

Acknowledgments

The authors gratefully acknowledge financial support (junior/senior research fellowship; Ref: 3/1/3JRF-2011/HRD-104) from the Indian Council of Medical Research (ICMR), New Delhi for this study.

Indian Journal of Psychiatry Volume 62, Issue 4, July-August 2020
Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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