

# ***Possible Cognitive Mechanisms Behind the Interaction Between Depression and Drug Abuse: The Role of Executive Function and Emotion Regulation***

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**Abstract:** Recent studies of the comorbidity of depression (major depressive disorder) and drug abuse have provided strong evidence for their interactions, but comprehensive analyses that include the cognitive mechanisms behind these interactions are still lacking. This paper synthesises the relevant literature on the effects of depression and drug abuse on and by cognitive function, and constructs a model of the cognitive mechanisms involving depression and drug abuse by introducing the cognitive functions of executive function and emotion regulation (ER). That is, both depression and drug abuse could impair an individual's executive function, which in turn hinders effective ER, and failed ER in turn causes or exacerbates depressive situations and leads to a greater risk of drug abuse or more severe drug abuse. This modelling also confirms the possibility of intervention in cognitive processes to alleviate depression and drug abuse at the same time. In the future, the neuroscientific perspective can be further complemented and refined.

**Keywords:** major depressive disorder, drug abuse, executive function, emotion regulation

## **1. Introduction**

Depression and drug abuse are both psychophysical problems that have a serious negative impact on patients' quality of life, and their comorbidity is well established. Existing studies have concluded that depression is significantly associated with drug abuse and that the severity of drug abuse is positively correlated with depression scores [1]. This may be due to inappropriate attempts at self-medication by individuals with depression, or it may be that the neurobiological changes caused by drug abuse predispose individuals to depression [2]. Much research has explored the cognitive mechanisms behind depression and the emotion regulation factors that influence drug abuse, but the interactions between depression and drug abuse through these mediators remain understudied. This review explores the mechanisms by which depression and drug abuse interact, considering executive function and emotion regulation as mediators, and constructs a simple model based on the possible mechanisms.

## **2. Concepts**

### **2.1. Depression**

Depression (major depressive disorder) is a chronic and recurrent disorder that may occur in people of all ages. It includes abnormalities in affect and mood, impaired neurovegetative function, negative cognition, and psychomotor activity [3]. Individuals with depression experience prolonged periods of depressed mood and loss of interest, which can have a serious negative impact on their school, work, and life.

### **2.2. Drug Abuse**

Drug abuse is the excessive, dysfunctional, or compulsive use of drugs for non-medical purposes [4]. The individual becomes physically, and (or) psychologically dependent on the drug and may experience psychological, physiological and social problems. It is worth noting that the boundaries between drug use, abuse, and addiction are not very clear. Therefore, this paper will not explore this categorisation in detail.

### **2.3. Executive Function**

Executive function (EF) is a set of neurocognitive skills that are influenced by a combination of social environment, genetic factors, and individual circumstances, and it involves goal-directed problem solving [5]. EF skills include working memory (updating), inhibitory control, and set shifting/flexibility. These skills can be trained, and brain structure and function will change accordingly.

### **2.4. Emotion Regulation**

Emotion regulation (ER) is the ability to regulate and control the emotional state. The extended process model of ER shows that ER is divided into identification, selection, and implementation stages, which are interrelated and difficult to exist independently [6]. People employ particular tactics to control the strength, length, and caliber of their emotional reactions.

## **3. Executive Function and Emotion Regulation**

An experimental study by Mohammed, Kosonogov, and Lyusin showed that executive function could influence emotion regulation. To more specifically investigate the relationship between EF and ER by modelling at the component level, the experimenters restricted executive function to three aspects as updating, shifting, and inhibition [7]. Meanwhile, ER was classified into five components as situation selection, situation modification, attentional deployment, cognitive change (cognitive reappraisal), and response modulation (expressive suppression). Subjects' accuracy rates and reaction times were measured. Subjects were then asked to perform an emotion regulation task while their psychophysiological data were collected, and at the end of the test, the Gross Emotion Regulation Questionnaire was given to the participants. As most of the final variable results did not fit the normal distribution, statistical analysis was performed using nonparametric methods. A Friedman analysis was used to test the validity of the ER strategies. Finally, the relationship between executive function and ER was examined using the Spearman rank correlation.

The results of the experiment were that updating was positively correlated with cognitive reappraisal, meanwhile, the effect of emotion regulation was also confirmed by measuring heart rate. This means that people with greater updating ability can use the cognitive reappraisal strategy more effectively to regulate their emotions and that people who use the suppression strategy more often in

their lives perform better on inhibition tasks. This suggests that inhibition in executive function has a positive correlation with suppression ability. However, shifting between different tasks showed no significant correlation with emotion regulation.

Similar conclusions were presented in a review of research by Schmeichel and Tang that inhibition could facilitate more objective cognitive reappraisal by suppressing subjective emotional responses, and higher levels of inhibition may reduce negative emotions when recalling emotional events [8]. Working memory capacity, including updating, helps individuals organise cognitive resources for reappraisal, which in turn reduces perceived negative emotions.

The above papers have reached different conclusions about the effects of different components of executive function, which may be due to the different experimental paradigms used and the tendency of subjects to use different emotion regulation strategies for different contexts. These differences need to be further explored and synthesised. Overall, executive function as a foundation may influence an individual's performance in emotion regulation. This may mean that people with higher levels of executive function are able to use more effective strategies when they need to control their emotions and therefore have better ability for emotion regulation.

#### 4. Emotion Regulation and Depression

In recent years, the search for treatments for depression has shifted towards interventions that target emotion regulation skills. The long-term effects of ER on depression were examined by Berking et al. A health magazine in Germany was used to recruit subjects. The subject was given a baseline assessment of their emotional regulation and mental health, and the connection was investigated. Five years later, 131 subjects completed measures of emotion regulation and depression severity utilizing the Center of Epidemiological Studies Depression Scale and the Emotion-Regulation Skills Questionnaire in German [9].

Several  $\chi^2$  and independent t-tests were conducted to compare assessment data such as emotion regulation and depression scores before and after five years. A cross-lagged panel containing continuous assessments of two or more variables throughout time was utilized to quantify the relationship between depressed symptoms and emotion regulation. Models with four latent variables, namely emotion regulation at time 1 and time 2 (five years later) and depression at time 1 and time 2, were also constructed. The scaling method was fixed factor loadings.

The results analysed the relationship between emotion regulation at time 1 and depression at time 2. Successful use of ER skills had a significant effect on the level of depression five years later, whereas depressive symptoms did not have a significant effect on successful emotion regulation. Thus, successful emotion regulation skills at baseline had a negative predictive effect on depression. In conclusion, the results showed that a weakness in emotion control contributed to the onset of depression and predicted the severity of the condition later on. The relationship between ER and the emergence and development of various levels of depressive symptoms (depressive symptom severity, first episode status, recurrent episodes, and chronic depression) was not broken down in the study, which included non-clinical participants.

A review in 2014 summarised some of the clinical studies on depression, showing that ineffective or inappropriate emotional regulation affect the development and maintenance of depression [10]. In particular, depressed patients tended to have negative perceptions of their emotions, and this tendency increased with the severity of depression. However, the predictive relationship between depression and emotion regulation of negative emotions has not been explored in detail.

## 5. Depression and Executive Function

One of the hallmarks of depression is cognitive impairment. The research has demonstrated the existence of executive dysfunction in depressed individuals by testing executive function in young depressed inpatients [11]. The MINI International Neuropsychiatric Interview was administered, along with the Montgomery-Asberg and Beckman Depression Rating Scale, to a hospital-based experimental group of participants who met the diagnostic criteria for major depressive disorder. At the same time, subjects of similar age, IQ, and educational level to the experimental group were selected as controls. All subjects underwent clinical and neuropsychological assessments and were tested on their ability of updating, inhibition, and shifting through a series of executive function tasks. The results of the experiment explained the lower performance of depressed patients than controls on the n-Back task as an impairment of working memory updating. Deficits in other aspects of executive function, such as shifting and inhibition, were also found in other tasks.

A similar study reviewed the literature published between 1993 and 2020. The study searched Medline, Pubmed, and Web of Science databases for studies of executive function tasks, such as the Stroop Colour Word Test, in depressed patients, including healthy controls [12]. The results of the review suggested that neuropsychological deficits might be associated with depression and show executive dysfunction. One hypothesis for the cognitive deficits was that processing speed was slowed in depressed patients. As a component of higher cognitive functioning, slowed cognitive speed impaired the ability of depressed individuals to process complex tasks. Another hypothesis distinguished between automatic and effortful tasks and speculated that, due to a specific executive deficit, depressed individuals would require greater effort to perform effortful tasks. The subjects in the literature reviewed were heterogeneous in terms of depression subtypes, age, symptom severity, and number of episode, but generally described the impairment of executive function by depression.

## 6. Emotion Regulation and Drug Abuse

An article published in 1986 analysing drug dependence from a psychodynamic perspective examined individuals and groups at various phases and circumstances related to drug abuse [13]. This article explained that individuals abuse medicines, especially those that regulate mood, as a form of coping mechanism for insufficient internal control systems, and hypothesised that the failure to use and process emotions could result in extreme stress, leading individuals to engage in regressive behaviours and use inappropriate defence mechanisms, manifested as a failure of emotion regulation.

A study by Bonn-Miller, Vujanovic, and Zvolensky investigated the relationship between emotional dysregulation and drug abuse [14]. The study investigated the subjects' history of psychiatric disorders and cannabis use, assessed the subjects' motivation to smoke cannabis using the Marijuana Motives Measure. Researchers used the Difficulties in Emotion Regulation Scale to evaluate the respondents' ability to accept and control their emotions. According to the study, cannabis consumption was linked to depressive mood disorders. The likelihood that subjects would experience positive and negative affective states was also assessed using the Positive Affect Negative Affect Scale. The study also assessed the anxiety sensitivity of the subjects. Statistical results, which excluded confounding by other motivations, showed that low tolerance for emotional experience was significantly associated with motivation to use cannabis. Furthermore, emotional dysregulation was associated with the use of emotionally related drugs. This may suggest that cannabis users choose to use cannabis to regulate their emotions because of a deficit in psychological emotion regulation.

Emotion regulation was shown to be one of the most vital elements driving drug abuse in a review of the relationship between emotion regulation and substance use [15]. The review conducted overall descriptive and frequency analyses of the data from the articles and analysed each emotion regulation construct independently. With few exceptions, both positive and negative emotion dysregulation were

associated with drug abuse, with deficit in emotion regulation abilities and negative impulses having a more significant effect on drug abuse. This implies that drug abuse is more prevalent in those who have trouble controlling their emotions.

## 7. Drug Abuse and Executive Function

A study in 2007 of substance abusers showed that substance dependent individuals have executive function impairments [16]. The study recruited 33 individuals who satisfied the DSM-IV criteria for alcohol or drug abuse as an experimental group and 19 healthy individuals who were similar to the experimental group in all respects as a control group to compare the effects of substance dependence on executive function. In the experiment, the delayed non-match to sample task was completed by the subjects on a computer to test their capacity of working memory and the Iowa Gambling Task to test the subjects' decision-making ability. The data collected from the experiment were analysed using repeated measures ANOVA. The result showed that the experimental group with methamphetamine abuse performed significantly lower than the other groups in both tasks. This suggested that, in the study or experimental setting, drug abusers had deficits in executive function in terms of updating and decision making compared to normal individuals. Because substance abusers tended to use a variety of substances together, the effects of drugs and alcohol were not completely separated in this study. As a result, the unique effects of each substance were not examined separately.

A review published in 2003 summarised the mechanisms of drug abuse, namely that drugs had reinforced the persistence and escalation of drug abuse by affecting individuals' reward mechanisms and integrated the effects of drug abuse on executive function through the findings of pre-existing research [17]. Drug abusers have shown clear deficits in executive function. From a neuropharmacological and neuroanatomical perspective, most drug abuse directly or indirectly alters prefrontal dopaminergic function. Prefrontal brain regions are involved in higher cognitive functions in humans, and dopaminergic function plays a significant role in prefrontal function. Drug-induced dopaminergic activity or inhibition may impair prefrontal function by disrupting the inhibitory processes that control and regulate behaviour, which in turn impedes an individual's executive function.

## 8. Discussion

By linking and integrating some of the existing studies, this review provides a simple model of depression and drug abuse, and of ER and EF, which may play a mediating role. That is, depression may affect patients' higher cognitive functions, causing them to be slower and more effortful in cognitive activities, which in turn impairs executive function. Meanwhile, drug abuse also impairs cognitive function by damaging an individual's prefrontal cortex, resulting in a deficit in executive function. Individuals with weaker executive function tend to use ineffective or inappropriate emotion regulation strategies and are less adept at using cognitive reappraisal, demonstrating poorer emotion regulation. Furthermore, deficits in emotion regulation make individuals more vulnerable to the lingering effects of negative emotions, thereby facilitating the onset, development, or recurrence of depression. Correspondingly, emotion dysregulation also results in individuals having more difficulty tolerating negative emotions and more frequent emotion regulation failures. Individuals who are not good at emotion regulation are then more likely than healthy individuals to view drug use as an emotion regulation strategy and to use it inappropriately, creating a negative cycle of depression and drug abuse.

The literature selected for this review consists mostly of correlational studies between different components, and its causal assumptions are based more on previous studies and inferences. Therefore, the causal order of the model is not absolute, and there is the possibility of reverse causation, which



needs to be further introduced into experiments based on the clear causation paradigm and more longitudinal studies with some period. This review did not categorise and integrate the depression and drug abuse groups in the literature. There was also some heterogeneity in the subjects selected for each experiment based on age, gender, education, and region.

The review found that it is possible to regulate and train emotional regulation in co-occurring depression and substance abuse disorders and to provide a stable environment to generate emotional support to alleviate the symptoms of depression and drug abuse. At the same time, the elements that make up the model, such as the episodes and subtypes of depression and the nature and duration of drug abuse, can be further subdivided to explore in depth the specific associations of each factor. In addition, current research in brain neuroscience can be incorporated into the model to provide a more complete and systematic framework for further research and understanding.

## 9. Conclusion

This review introduces two mediating factors, executive function, and emotion regulation, to demonstrate that depression and drug abuse have a reciprocal effect, which means that those who abuse drugs are more likely to experience depression., and vice versa. A model that integrates the interplay of the factors is also provided. This review provides a more nuanced perspective on understanding and integrating the relationship between depression and drug abuse and raises the possibility of treating both depression and drug abuse by moderating mediating factors. Due to the heterogeneity of the sample, the conclusions of the review may not apply to all groups. Similarly, the neuroscientific rationale basis for the interaction between depression and drug abuse needs further investigation.

## References

- [1] Coelho R, Rangel R, Ramos E, Martins A, Prata J and Barros H 2000 *Depression and the severity of substance abuse Psychopathology* 33 103–9.
- [2] Volkow N D 2004 *The Reality of Comorbidity: Depression and Drug Abuse Biol. Psychiat.* 56 714–7.
- [3] Fava M and Kendler K S 2000 *Major depressive disorder Neuron* 28 335–41.
- [4] Britannica T, Drug abuse (2023) *Encyclopedia Britannica*, Available online at: <https://www.britannica.com/science/drug-abuse>.
- [5] Carlson S M, Zelazo P D and Faja S 2013 *The Oxford Handbook of Developmental Psychology Oxford: Oxford University Press*.
- [6] Gross J J 2015 *Emotion regulation: Current status and future prospects Psychol. Inq.* 26 1–26.
- [7] Mohammed A R, Kosonogov V and Lyusin D 2022 *Is emotion regulation impacted by executive functions? An experimental study Scand. J. Psychol.* 63 182–90.
- [8] Schmeichel B J and Tang D 2015 *Individual differences in executive functioning and their relationship to emotional processes and responses Curr. Dir. Psychol. Sci.* 24 93–8.
- [9] Berking M, Wirtz C M, Svaldi J and Hofmann S G 2014 *Emotion regulation predicts symptoms of depression over five years Behav. Res. Ther.* 57 13–20.
- [10] Compare A, Zarbo C, Shonin E, Van Gordon W and Marconi C 2014 *Emotional Regulation and Depression: A Potential Mediator between Heart and Mind Cardiovasc. Psych. Neur.* 2014 324374.
- [11] Harvey P O, Le Bastard G, Pochon J B, Levy R, Allilaire J F, Dubois B and Fossati P 2004 *Executive functions and updating of the contents of working memory in unipolar depression J. Psychiatr. Res.* 38 567–76.
- [12] Nuño L, Gómez-Benito J, Carmona V R and Pino O 2021 *A Systematic Review of Executive Function and Information Processing Speed in Major Depression Disorder Brain Sci.* 11 147.
- [13] Treece C and Khantzian E J 1986 *Psychodynamic factors in the development of drug dependence Psychiatr. Clin. North. Am.* 9 399–412.
- [14] Bonn-Miller M O, Vujanovic A A and Zvolensky M J 2008 *Emotional dysregulation: association with coping-oriented marijuana use motives among current marijuana users Subst. Use Misuse* 43 1653–65.
- [15] Weiss N H, Kiefer R, Goncharenko S, Raudales A M, Forkus S R, Schick M R and Contractor A A 2022 *Emotion regulation and substance use: A meta-analysis Drug Alcohol Depen.* 230 109131.

- [16] *Gonzalez R, Bechara A and Martin E M 2007 Executive functions among individuals with methamphetamine or alcohol as drugs of choice: preliminary observations J. Clin. Exp. Neuropsych. 29 155–9.*
- [17] *Fillmore M T 2003 Drug abuse as a problem of impaired control: current approaches and findings Behav. Cognit. Neurosci. Rev. 2 179–97.*