

# Emotion regulation and executive functions in adults with substance use disorder

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## Abstract

The current study aims to examine the correlation between emotion regulation (ER) and executive functions (EFs) in the context of substance use disorder (SUD). The Behavior Rating Inventory of Executive Function- Adult Version (BRIEF-A), and the Difficulties in Emotion Regulation Scale-16 (DERS-16), were given to 38 male participants with SUD (between 19-56years) receiving treatment at Irada Hospital for Mental Health in Jazan City- Saudi Arabia. The empirical data were described, and the correlations between the key variables were analyzed using spearman's rank correlation test. The results revealed a moderate positive significant relationship between the EF problems, as assessed by the Global Executive Composite (GEC; BRIEF-A) and DERS scores. In the light of these findings, we confirm the association between ER and EFs, and we recommend developing the clinical practice settings of SUD healthcare in the Arab world, by including treatment programs focusing specifically on both ER strategies and EFs abilities.

**Keywords:** emotion regulation; executive function; substance use disorder.

## Introduction

substance use disorder (SUD) is a complex condition typified by compulsive and uncontrolled use of a substance despite its harmful implications. It is classified as a chronic and relapsing brain disorder due to the structural and functional abnormalities in brain circuits involved with the reward system, emotional experience, and self-control (Volkow et al., 2016), as well as prefrontal cortex (PFC) involved in EFs and ER (Kober, 2014). According to the Fifth Edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-V), SUD Leads to clinically significant distress characterized by the existence of symptoms such as tolerance, withdrawal, persistence use despite wishes to stop, continued use despite known harmful consequences, and the loss of regulatory control over drug cravings (Kober, 2014).

SUD may be caused by a combination of genetic, cognitive, behavioral, and environmental factors that interact across multiple levels (Kober, 2014). In recent years, given the challenges that addicted individuals have with self-control, craving, and the tendency-avoidance conflict (Aldao et al., 2010), interest has increased in examining the links between ER and SUD.

ER is a multidimensional construct that includes implicit and explicit processes that aim to modify or maintain the current or prospective emotional state in terms of intensity, quality, and durability (Parolin et al., 2017), in order to sustain and maintain goal-oriented behavior (Etkin et al., 2015; Tamir, 2016). Effective ER is generally accepted to be critical to mental health, social adjustment, and psychological well-being (Robertson et al., 2012; Parolin et al., 2017). While emotion dysregulation (EDR) leads to various mental disorders (Aldao et al., 2010), including borderline personality disorder (BPD) (Dixon-Gordon et al., 2020), post-traumatic stress disorder (PTSD) (Tull et al., 2007), aggressive behavior (AB) (Robertson et al., 2012), depression (Mehrabi et al., 2014), anxiety (Cisler et al., 2010), and SUD (Kun & Demetrovics, 2010).

In the context of SUD, there is a large body of evidence supporting the vital role of ER in the emergence, development, and maintenance of addiction-related symptoms (Wilcox et al., 2016; Petit et al., 2015; Kober, 2014). It appears that EDR increases SUD severity (Tull et al., 2015), drug consumption (Fucito et al., 2010; Berking et al., 2011), and the intense desire to consume (Petit et al., 2015), and predicts relapse to substance use (Witkiewitz and Wu, 2010). Similarly, EDR is widely common among SUD populations (e.g., Fox et al., 2008), which may contribute to the clinical course of the disorder (Kober, 2014).

According to Kober (2014), the correlation between ER and SUDs may take three forms; firstly, drug use as an ER strategy. Many drugs and stimulants (e.g., alcohol, marijuana, cocaine, amphetamines, heroin, and morphine) are described as euphoric, increasing positive emotion (Jaffe & Jaffe, 1989), and alleviating negative emotional states (e.g., anxiety, sadness, and pain). The self-medication hypothesis (Khantzian, 1987; 1997) proposes that unpleasant affective states predispose individuals to drug use. Le Moal (2009) sees that taking drugs is not the problem but a solution to dealing with preexisting problems. In line with these facts, it is proposed that drug use serves to regulate negative emotions (i.e., preexisting psychiatric disorders), craving experiences (Childress et al., 1993; Shiffman et al., 2013), reduce chronic pain (Morasco et al., 2011), and increase positive emotions. Secondly, EDR is an early risk factor. Individual differences in ER (which manifest as early as preschool) may predate the development

of SUD and could therefore be conceptualized as a risk factor predicting SUD onset. For example, in the "marshmallow test" experiments (Mischel et al., 2011), the ability to delay gratification, and regulate emotions like desire in childhood (preschool) are related to better social-cognitive and emotional coping in adolescence, and importantly, it reduces the possibility to use crack cocaine in adulthood. Similarly, poor self-control in childhood is indeed a risk factor for drug use and the development of SUD (Moffitt et al., 2011). In addition, trait impulsivity in childhood has been repeatedly associated with the development of SUD in later adolescence and adulthood (Ivanov et al., 2011; Verdejo-García et al., 2008). Third, EDR is a SUD symptom. SUD individuals frequently reported higher difficulties in ER skills (i.e., emotional clarity, developing effective emotional coping strategies, and impulse control) compared to the controlled group (Fox et al., 2008; Wilcox and Adinoff, 2015). In addition to impairments in emotional response to positive stimuli (Aguilar de Arcos et al., 2008), and insensitivity to natural rewards (Elman & Borsook, 2016). Such difficulties were linked to increased drug use (Berking et al., 2011), sustained and exacerbated addiction, and increasing reliance on substances to alleviate dysphoria and anxious arousal (for a review, see Garland et al., 2018).

In neuropsychological literature, ER occurs through interactions between cortical neural systems (e.g., dorsolateral PFC, ventromedial PFC, ventrolateral PFC, and dorsal ACC), and subcortical neural systems (e.g., amygdala, striatum) (Garland et al., 2018). In line with this fact, ER deficits and the loss of control over craving in SUDs were explained by the long-term functional and structural abnormalities in these brain areas (PFC) due to chronic drug use. Kober (2014, pp. 437-438) says, "chronic drug use may lead to a vicious cycle, in which impaired ER leads to drug use, and drug use may further lead to impaired ER".

The activity of prefrontal cortical areas during ER primarily reflects the higher cognitive processing of emotional stimuli and response monitoring. Hence, it has been suggested in the neuropsychological literature that the deficit in ER among addicted patients is associated with executive dysfunctions (e.g., Formiga et al., 2021; Marceau et al., 2018).

Along with the deficits in ER reported by SUD patients, EFs deficits are widely common in SUD populations (Fernández-Serrano et al., 2010; Hester et al., 2010; Day et al., 2015; Durazzo et al., 2012; Mchale & Hunt, 2008; Woicik et al., 2011). Deficits in both EFs and ER represent a risk of beginning drug use, facilitate the transition from recreational use to SUDs (George & Koop, 2010), and influence treatment adherence and recovery (Formiga et al., 2021).

Despite clear deficits in each of these domains, there is a paucity of studies directly examining the relationship between EFs and ER in SUD populations. Looking at the scientific publications, it seems that there are only two studies that address this problem. For instance, in an across-sectional study (Marceau et al., 2018), aimed to examine the relationship between EFs and ER in SUD. A female sample attending residential SUD treatment completed a group of questionnaires. The Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer, 2004), and Behavior Rating Inventory of Executive Function-Adult Version (BRIEF-A; Roth et al., 2005), in addition to neuropsychological assessments of EFs (Wechsler Adult Intelligence Scale; Color-Word Interference Test; Delis-Kaplan Executive Function System). As a result, the inventory-based assessment of EFs was uniquely related to difficulties in ER. In basic performance-based EFs, task-switching (compared with working memory and

inhibition) was the only aspect associated with ER difficulties (Marceau et al., 2018). Similarly, using an across-sectional design, the EFs and ER performance was analyzed in a sample consisting of 130 volunteers divided into three groups: Group (1), composed of participants who did not meet the diagnostic criteria for any type of SUD; group (2), with users with alcohol and/or tobacco use disorder; and group (3), with users with SUD of poly-substances. The results indicated group (2) presented a worse performance in EFs and ER when compared to group (1), and greater damage in-group (3). These findings support the idea that EFs, ER, and SUD are related (Formiga et al., 2021).

In summary, EF and ER are strongly related (Anderson et al., 2002; Sperduti et al., 2017), and both are impaired in SUD (Goldstein & Volkow, 2011). Yet their correlations in SUD populations are not extensively established. In the recent study by Marceau and her colleagues (2018), the experiment has consisted exclusively of females and no male participants. This makes the results inconclusive, given that gender effects are present in all present variables, including SUD (McHugh et al., 2018), EFs (Gaillard et al., 2021), and ER (Goubet and Chryssikou, 2019), and may potentially lead to diversity in SUD treatment responses. Our contribution is, in particular, to extend the findings (Marceau et al., 2018) about correlation between ER and EFs in females to include males sample to ascertain whether comparable or divergent relationships exist. Knowing the nature of these impairments aids in determining the possibilities of diagnosis, prognosis, treatment, and monitoring of the evolution of the condition (Marceau et al., 2018).

## Method

### 1. Participants

Male participants (N = 38) between 19 and 56 years old were recruited from Irada Hospital for Mental Health in Jazan City– Saudi Arabia. Inclusion criteria for the study were (1) diagnosis of substance abuse/dependence, based on DSM-V criteria by a specialist medicine in addiction medicine. (2) A minimum abstinence period of 7 days (with confirmation of detoxification as a prerequisite of entry to treatment). (3) Absence of any neurological, infectious, or other disease affecting the central nervous system (e.g., epileptic seizures, brain tumor, encephalitis, stroke, meningitis, multiple sclerosis), and (4) Arabic as a native language.

### 2. Material

In the current study, we relied on two tests. The BRIEF-A (Roth et al., 2005), and the DERS- Brief version (DERS-16; Bjureberg, et al., 2016).

#### 2.1. Demographic questionnaire

A questionnaire was administered assessing common demographic variables (i.e., age, Education, Employment, Marital status), and SUD characteristics (i.e., Treatment length, Years of regular use, Abstinence period, substance).

## **2.2. Behavior Rating Inventory of Executive Function – Adult Version (BRIEF-A; Roth et al., 2005)**

The BRIEF-A is a 75-item self-report questionnaire containing nine non overlapping scales (Inhibit; Shift; Emotional Control; Self-Monitoring; Initiate; Working Memory; Plan/Organize; Task Monitor; Organization of Materials). Subjects were informed to reply to each item by answering “never,” “sometimes,” or “often” if they had experienced any problems with any of the listed behaviors in the previous month. For example, items include: “I don’t plan ahead for tasks” and “I forget what I am doing in the middle of things”. Similar to Marceau and colleague’s study (2018), The Global Executive Composite (GEC) was the outcome variable, which offers an overall summary score in which elevated scores indicate executive dysfunction. The BRIEF-A is a standardized rating scale designed to give insight into everyday behaviors related to specific domains of EFs in adults aged 18 to 90. It has been shown to be a more sensitive measure of EFs in patients with SUD than performance-based assessments (Hagen et al., 2016; Marceau et al., 2018). The BRIEF-A was adapted to the Arabic environment, and its reliability, validity, and consistency were significantly confirmed by Al-Shuqayrat (2015).

## **2.3. The Difficulties in Emotion Regulation Scale - Brief version (DERS-16)**

The DERS-16 (Bjureberg et al., 2016) is the brief version of the DERS (Gratz and Roemer, 2004), consisting of 16 items that cover 5 dimensions (nonacceptance of emotional responses, difficulties engaging in goal-directed behavior, impulse control difficulties, lack of emotional awareness, limited access to ER strategies, and lack of emotional clarity), in order to assess clinically relevant difficulties in ER. An item is presented to the participant, for example, “When I’m upset, I feel like I’m weak” - “I’m confused about how I feel”. Respondents are asked to indicate how often the items apply to themselves, with responses ranging between almost never, sometimes, about half the time, most of the time, and almost always. The DERS-16 has excellent internal consistency, good test-retest reliability, and good convergent and discriminant validity (Bjureberg et al., 2016). Recently, it has been translated into the Arabic language, and verified as to its validity, reliability, and consistency in the Saudi and Egyptian communities (See, Abbady et al., 2019).

## **3. Procedure**

We started with an exploratory visit to the Erada hospital's addiction unit. The contents of the research were presented to the hospitalized patients. Next, patients who agreed to participate were asked to fill out a questionnaire about their demographics, neuropsychiatric history, and SUD characteristics. In addition to medical reports. The study's criteria were met by 52 individuals. Finally, the psychological assessments (BRIEF-A, DERS-16) were given individually in a single session that ran from 10 to 15 minutes in a quiet room of the hospital. 14 of the 52 participants who have been interviewed were excluded due to response biases on the BRIEF-A scales.

## **Results**

All statistical calculations were performed using IBM SPSS software. Descriptive data (numbers, percentages, medians, and Standard Deviations) were obtained for all measures, and correlations using spearman's rank correlation test between all key variables were calculated. p-values <0.01 were considered statistically significant.

## Data descriptive

**Table 1**

Socio-demographic and substance use characteristics, along with ER and EFs scores medians

Variables	N (%)	M(SD)
Age	38	32.66 (10.11)
Education level/years		13.47 (2.85)
Elementary school	3 (7.9%)	
High school	14 (36.8%)	
Technical diploma	5 (13.2%)	
University	16 (42.1%)	
Marital status		
Married	12 (31.6%)	
Divorced	2 (5.3%)	
Single	24 (63.2%)	
Work		
Employed	21 (55.3%)	
Unemployed	11 (28.9%)	
Retired	1 (2.6%)	
Student	5 (13.2%)	
Primary substance of misuse		
Captagon	19 (50.0%)	
Hashish	7 (18.4%)	
Alcohol (to intoxication)	3 (7.9%)	
Amphetamine	3 (7.9%)	
Khat	2 (5.3%)	
Heroin	3 (7.9%)	
Cocaine	1 (2.6%)	
Treatment length (days)		102.53 (92.91)
Years of regular use		8.32 (9.03)
GEC		50.11 (10.31)
Executive dysfunction	2 (5.26%)	
EFs high problems	22 (57.9%)	
No problems in EFs	14 (36.84)	
DERS-16		50.76 (9.12)
High level difficulties (>58)	11 (28.94%)	
Moderate level difficulties (58 ≥ scores ≥ 45)	16 (42.12%)	
Low level difficulties (<45)	11 (28.94%)	

**Table 1.** displays an overview of the sample's socio-demographic and substance use characteristics, along with ER and EFs scores medians. Participants were, on average, in their early thirties (Mdn = 32.66 years, range 19–56), and had finished approximately 14 years of education (Mdn = 13.47 years, range 6–16). Captagon was reported by the half of participants (53%) as their primary substance of misuse, followed by Hashish (18.4%), Alcohol (7.9%), Amphetamine (7.9%), Heroin (7.9%), Khat (5.3%), and Cocaine (2.6%).

With regard to EFs, the majority of participants ( $n = 22$ ; nearly 58%) had more than 50 points on GEC scores ( $50 \leq t\text{-scores} < 65$ ), indicating that they have significant difficulties in daily life tasks related to EFs. However, these difficulties do not take a pathological form (executive dysfunction was detected ( $t\text{-score} \geq 65$ ) only in two participants). 37% of the sample ( $n= 14$ ) had no clinically elevated scores. With regard to ER problems, about 29 % ( $n=11$ ) of the 38 participants reported high scores in DERS-16 scale ( $>58$ ), and roughly 42 % ( $n=16$ ) of the sample exhibited moderate scores in DERS-16 scale ( $58 \geq \text{scores} \geq 45$ ).

### Analysis of correlations

**Table 2**

Spearman correlations between age, education, treatment length, EFs problems, and ER difficulties

	Age	Education	Treatment length	DERS-16	BRIEF-A
Age	1	-	-	-	-
Education	-0.42**	1	-	-	-
Treatment length	0.12	0.07	1	-	-
DERS-16	0.17	-0.24	-0.06	1	-
BRIEF-A	0.12	0.18	-0.2	0.51**	1

p-values <0.01

**Table 2** shows the spearman's correlation coefficient results run between age, education, treatment length, GEC scores, and DERS-16 scores. As stated in the table, we observe that the correlation coefficient between the BRIEF-A and the DERS ( $r= 0.51$ ,  $p<0.01$ ), demonstrating that there is a moderate association between ER difficulties and executive function problems. There were no significant associations between DERS-16 scores and other variables (such as age, education, treatment length). In conclusion, the results of the correlation analysis confirm our hypothesis that difficulties in ER in male participants with SUD are related to EFs problems.

### Discussion

While the relationship between EFs and ER in SUD has been explored in female participants (Marceau et al., 2018), we examined this correlation in male participants, in order to see if we would get similar results. Two psychological assessment was administered to participants diagnosed with SUD (BRIEF-A; DERS-16) along with a demographic questionnaire. Results showed moderate to high scores in the DERS-16 and BRIEF-A scales. The majority of participants reported frequent difficulties with daily life tasks associated with EFs and ER. This clearly indicates a high level of difficulties in ER and EFs among SUD populations. When evaluating the associations between ER difficulties and executive function deficit, we found a moderate positive relationship between the two variables. We did not find any effects of socio-demographic (age, education) or substance use characteristics (treatment length) on ER difficulties.

The current study's findings are to some extent consistent with the rare previous research (e.g., Marceau et al., 2018; Formiga et al., 2021). Although we found a positive correlation, it was not a strong compared to previous experiments. This variance can be explained partially by cultural differences, or the small sample size, or the

administration of variables...etc. The interpretation of the variance that occurs beyond the limits of this work. What concerns us is the interpretation of the correlation between the two variables. Nevertheless, it's too early to make satisfactory explanations about the relationship between ER and EFs in the context of SUD. This topic suffers from a lack of prior research studies. All the knowledge we have gained is from studying nonclinical populations. In general, there are three ways in which EFs and ER could be related as mentioned by Carlson and Wang (2007). Firstly, it has been proposed that EFs subserve effective ER (Hofmann et al., 2012; Schmeichel & Tang, 2015). Attentional control supports ER as it enables individuals to focus on goal-relevant information and ignore goal-irrelevant information (Ochsner & Gross, 2005). Working memory is thought to assist ER processes by enabling the ability to actively maintain and manipulate the perceptual and contextual information in the service of one's particular goal (Cochrane, 2011). Inhibitory control processes are important in facilitating the use of adaptive ER strategies, and reduce the use of more maladaptive ER strategies, and prevent impulsive responses and allow individuals to behave in ways that do not correspond with their actual feeling (Fernandes, 2017). Thus, Individuals who have problems with these components are more likely to experience emotional dysregulation and psychopathology (See, Cochrane, 2011). Secondly, ER is crucial for EFs (i.e., inhibition control), where better emotional coping frees up cognitive resources and effective problem solving. It is well known that unchecked emotions can impair reasoning and planning abilities (Carlson & Wang, 2007). Third, according to the iterative processing model by Zelazo and Cunningham (2007), ER and EFs are considered to be isomorphic, and bear a reciprocal relation, the precise nature of which will depend on the motivational significance of the problem and whether the problem itself is affective or cognitive (Carlson & Wang, 2007).

The current study, based on a neurocognitive cognitive perspective, supports the idea that emotion and cognition are linked intricately, and work together to process information and execute actions (García-Andrés et al., 2010). Hence, there is a reciprocal interactive relationship between ER and EFs, whereby better skills in one area are associated with better performance in another. There is an urgent need to conduct more experiments on the associations between emotional control and EFs in SUD populations.

However, we admit that our research has a number of methodological limitations that render the findings inconclusive. The first limitation is the small sample size, which stems from the fact that only a few participants who met our experimental criteria. Many of the patients who came to the hospital experienced psychiatric problems such as depression or anxiety, as well as other neurological conditions such as epilepsy, and we included only patients diagnosed with SUD without other diagnosed comorbidities. Another reason is that 14 of the 52 participants who have been interviewed were excluded due to response biases (related to the negativity, infrequency, and inconsistency scales) on the BRIEF-A scales.

The second limitation is related to the measure used to collect the data about EFs. While there is an indication that the BRIEF-A inventory is a sensitive measure of EFs in individuals with SUD (Hagen et al., 2016; Marceau et al., 2017), and have been widely used across several countries (Australia, Berry et al., 2021; Norway, Hagen et al., 2017; Sweden, Svanberg et al., 2017; USA, Clark et al., 2012). Its psychometric properties have still not been evaluated in Saudi community. The single study of the test's Arabization was carried out within Jordanian society (Al-Shuqayrat, 2015). The validity

and reliability of this measure for SUD patients in Saudi Arabia must be investigated to avoid any cultural biases. Moreover, there is strong evidence that executive function inventory and performance-based measures assess different underlying mental constructs (Toplak et al., 2013). The BRIEF-A inventory appears to assess behavioral difficulties related to EFs rather than basic EFs (such as inhibition, task-switching, and working memory) per se. In the previous study by Marceau et al. (2018), this difference was taken into account, and it was found that cognitive flexibility was the only executive ability that predicted difficulties in emotional regulation. In the current study, the assessment was based on inventory only, since we do not have performance-based measures that are valid, reliable, and appropriate for the selected sample. Therefore, our work is limited to studying the behavioral manifestations of EFs. A large number of performance-based neuropsychological measures for EFs in SUD are available and used in several clinical studies. Such as the Stroop test, the Go/No Go Task, the Wisconsin Card Sorting Test (WCST), the Trail Making Test, the Working Memory Index (WMI; Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV)), and the Color-Word Interference Test (Delis-Kaplan Executive Function System (D-KEFS)) (e.g., Verdejo-García et al., 2006; Hagen et al., 2016; Marceau et al., 2017). However, studies are still needed to assess their validity and reliability with SUD patients in the Arabic environment.

Another limitation must be noted. During the statistical processing of the data, no sequential hierarchical regression between demographic factors, disorder characteristics, and DERS-16 scores (as the dependent variable) was employed since there is no statistically significant correlation was found. We only checked out the correlations between ER and EFs. However, we emphasize the importance of employing sequential hierarchical regression in future studies (in case there is a significant correlation) to identify demographic variables and SUD characteristics that predict emotion dysregulation.

Given the methodological limitations in the current study associated with sample size and tools used; in addition to the lack of prior studies, it appears that generalizing any results remains premature. The current study's findings might be interpreted as preliminary exploratory data that support the positive association between emotional regulation difficulties and executive function-related behavioral challenges in SUD. There is an urgent need to conduct more research and experiments on this topic.

Future research interested in this topic needs to include large samples from diverse socioeconomic backgrounds, taking into consideration the severity of the disorder and comorbidity (i.e., anxiety, depression), general cognitive functioning, and various neuropsychological abilities in order to determine their effect on the relationship between ER and EFs. Incorporating laboratory-based measures of ER and EFs can also be beneficial to capture individual differences in these domains more robustly. In the Arab context, the primary objective of the research should focus on translating, adapting, and validating the psychometric properties of measurement tools, or developing new tests that fit cultural specificities in Arab countries.

## Conclusion

The results of the current study indicate that difficulties in ER in males with SUD are associated with difficulties in EFs. Despite the limitations mentioned above, the importance of the current findings lies in the fact that they are preliminary empirical

data that provides a major step toward integrating cognitive and emotional factors into clinical explanatory models of SUD. Future research interested in this topic needs to include large samples from diverse socioeconomic backgrounds, taking into consideration the severity of the disorder and comorbidity (i.e., anxiety, depression, and epilepsy...etc.), general cognitive functioning, and various neuropsychological abilities in order to determine their effect on the relationship between ER and EFs. Incorporating laboratory-based measures of ER and EFs can also be beneficial to capture individual differences in these domains more robustly. In the Arab context, the primary objective of the research should focus on translating, adapting, and validating the psychometric properties of measurement tools, or developing new tests that fit cultural specificities in Arab countries.

In sum, this paper highlights the need to develop treatment strategies focusing specifically on both ER difficulties and EFs problems within clinical practice settings of SUD recovery in the Arab world.

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