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# Executive functions and emotion regulation in substance use disorder

*Funções executivas e regulação emocional no transtorno por uso de substâncias*

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## ABSTRACT

**Objective:** The executive functions (EF) and emotion regulation (ER) and their relationship with the substance use disorder (SUD) were analyzed. **Methods:** A cross-sectional design was used. The sample consisted of 130 volunteers divided into three groups: group 01 (n = 60), composed of participants who did not meet the diagnostic criteria for any type of SUD; group 02 (n = 51), with users with alcohol and/or tobacco use disorder; group 03 (n = 19), with users with multiple substance use disorder, including at least one illicit substance. **Results:** Group 02 presented worse performance in EF and ER when compared to group 01, and showed a significant correlation between the working memory and the use of maladaptive ER. Group 03 showed great losses in EF and ER when compared to the other groups. **Conclusion:** This study supports the idea that EF, ER and SUD are related. In addition, it was observed that people with SUD had worse performance in EF and ER when compared to people without SUD, greater damage being observed in people with SUD of polysubstances.

## KEYWORDS

Executive functions, emotion regulation, substance use disorder, drug, drug users.

## RESUMO

**Objetivo:** Analisaram-se as funções executivas (FE) e a regulação emocional (RE) e a sua relação com o transtorno por uso de substâncias (TUS). **Métodos:** Utilizou-se um delineamento transversal. A amostra foi composta por 130 voluntários, divididos em três grupos: grupo 01 (n = 60), composto pelos participantes que não preenchem os critérios diagnósticos para nenhum tipo de TUS; grupo 02 (n = 51), com os entrevistados com TUS de álcool e/ou cigarro; grupo 03 (n = 19), com os voluntários com TUS de polissubstâncias, incluindo pelo menos uma substância ilícita. **Resultados:** O grupo 02 apresentou pior desempenho nas FE e na RE, quando comparado ao grupo 01, e exibiu uma correlação significativa entre a memória de trabalho e o uso de RE desadaptativa. O grupo 03 apresentou maior prejuízo nas FE e na RE, quando comparado aos demais grupos. **Conclusão:** Este estudo apoia a ideia de que as FE, a RE e o TUS estão relacionados. Além disso, observou-se que as pessoas com TUS apresentaram pior desempenho nas FE e na RE, quando comparadas com as pessoas sem o TUS, sendo as com TUS de polissubstâncias com maior prejuízo.

## PALAVRAS-CHAVE

Funções executivas, regulação emocional, transtorno por uso de substâncias, drogas, usuários de drogas.

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## INTRODUCTION

Executive functions (EF) are essential skills for the development of human beings in cognitive, social and psychological aspects<sup>1</sup>. Some researchers consider an EF as a unitary process, while others suggest it is a multidimensional concept formed by related and independent abilities<sup>2</sup>. This article presents research results based on the multidimensional concept, according to Diamond's theory<sup>1</sup>, which considers that the EF is formed by three main nuclei: inhibitory control (IC), working memory (WM) and cognitive flexibility (CF). The IC enables the person to resist to impulses or automatic habits according to appropriate behaviors and aligned with personal or social goals; the WM keeps information in mind and manipulates it, and may even evoke its own goals to assist the IC, while CF allows us to act creatively and to elaborate new perspectives, being flexible to adapt when changes emerge<sup>1</sup>.

Drug users who meet the criteria for substance use disorder (SUD) presented impaired performance in alcohol-related EF<sup>3,4</sup>, tobacco<sup>5</sup>, marijuana<sup>6</sup> and cocaine<sup>7</sup> when compared to healthy controls. However, it is still a challenge for science to infer the consequences of using only one drug in EF, since most users use alcohol or tobacco alone, or switch to polysubstances, including at least one illicit drug. In this sense, research has been carried out evaluating EF in multi-users, who also showed deficits when compared to non-users<sup>8,9</sup>. A study compared a control group, people with SUD (alcohol) and people with SUD (alcohol and other substances), in which the latter group performed unfavorably in EF and also in the process of emotional regulation<sup>10</sup>.

Emotion regulation, according to Gross<sup>11</sup>, is the process of modifying the intensity, duration or type of emotional response to maintain adaptive behaviors. The strategies used to regulate the emotions, according to the author mentioned, can be the *up* and *down* regulation, when they aim to reduce or to increase the effects of the emotions, respectively<sup>12</sup>. Based on this premise, Nelis *et al.*<sup>13</sup> proposed that ER strategies may be adaptive, functional, maladaptive or dysfunctional. In contexts that elicit positive emotions, ER strategies may be adaptive or maladaptive, as they increase or decrease the effects of these emotions, respectively. In scenarios that trigger negative emotions, they may be functional or dysfunctional, by decreasing or increasing the effects of these emotions, in this order<sup>13,14</sup>.

The difficulties in the ER are associated with the consumption of drugs<sup>15,16</sup>, with the emergence and maintenance of SUD<sup>17,18</sup> and the intense desire to consume<sup>17,19</sup>. In this perspective, it is understood that individuals with SUD use drugs to temporarily relieve their desire, thus generating a vicious cycle of increasing desire and use<sup>18</sup> and that, after several years of consumption, substance use constitutes the main strategy of ER<sup>19</sup>.

The executive functions and the emotion regulation are closely associated<sup>20-22</sup> and better skills in one area are associated with the better performance in another<sup>20</sup> and both suffer losses when there is SUD<sup>23</sup>. It is conjectured that strong abilities in EF protect the person against the early start of substance use<sup>24</sup> and ER skills help maintaining abstinence during treatment and in the first few months after treatment<sup>16</sup>.

The losses in EF and ER influence the treatment and recovery of people with SUD. Deficits in EF and ER in users represent a risk of beginning drug use and facilitate the transition from recreational use to SUD<sup>25</sup>, negatively influencing treatment adherence and use<sup>26</sup> and interfering in the motivational stage to change addictive behavior<sup>3</sup>. Knowing the extent of these damages helps to infer the possibilities of treatment, diagnosis, prognosis and monitoring of the evolution of the condition<sup>26</sup>.

Despite the literature on the effects of drug use in the EF and ER, there are few studies covering the relationship of the two variables concomitantly in users. The main objective of this study was to analyze the executive functions and the emotion regulation and their relationship with the substance use disorder. It should be noted that this research presents the differential of comparing the results of people with alcohol use disorder and/or smokers with polysubstance users and monosubstance users who did not meet the criteria for SUD. Another aim was to understand the correlation between ER strategies (adaptive, maladaptive, functional or dysfunctional strategies) with the EF (IC, WM or CF).

## METHODS

### Research design

This is a cross-sectional with quantitative approach and non-probabilistic sampling of intentional type.

### Research location

Data collection with people with SUD was carried out in two Psychosocial Care Centers for Alcohol and Other Drugs (CAPSad), which are reference centers specialized in the treatment of drug users, in the metropolitan region of João Pessoa, Paraíba, Brazil. CAPSad offers support to users with SUD, regardless of the type and number of substances, with the aim of reducing the damages. Data collection of the volunteers without SUD was performed in a place previously scheduled according to the choice and availability of the participant.

### Population and sample

Volunteers without SUD were recruited for convenience and their own interest, from the publicization of the

research in social media, in higher education institutions and by the interviewees who disseminated the research to other people. Participants with SUD were recruited in the institutions surveyed. Data collection with participants with SUD was composed of all those who attended the institution weekly during the collection period, who were willing to participate and who were in accordance with the inclusion and exclusion criteria.

Data collection was carried out by a team composed of four researchers: a psychologist with experience in the clinical care of drug users, specialization and master's degree in the area, and three students in the last year of the psychology course. Before the collection, the team conducted studies and discussions about the instruments to be used, the psychologist trained the team for the proper use of the instruments and the students practiced the application of the instruments. There was a leveling to reach the gold standard, in which the team interviewed the same volunteers and obtained similar results. These volunteers are not included in the sample, as the collection of these data was only for training and leveling the team.

Volunteers ( $n = 136$ ) were interviewed, however data of 6 participants with SUD were removed because they did not reach the cutoff point in the Mini-Examination of Mental State instrument. In this sense, the sample made up of 130 volunteers, divided into three groups, was analyzed. Group 01 ( $n = 60$ ), named as non-SUD, comprised of participants who did not meet the diagnostic criteria for any type of SUD, but who could be alcohol users ( $n = 41$ ) or tobacco ( $n=19$ ). Group 02 ( $n = 51$ ), with volunteers with alcohol use disorder only ( $n = 14$ ) or alcohol and tobacco use disorder ( $n = 37$ ). And group 03 ( $n = 19$ ), with users with multiple substance use disorder, including at least one of the illicit substances, named polysubstance users. In group 03, 80% ( $n = 15$ ) were alcohol dependent, 57.9% ( $n = 11$ ) were dependent on marijuana or derivatives, 47.3% ( $n = 9$ ) were dependent on cocaine/crack and 42, 1% ( $n = 8$ ) were dependent on cigarettes and derivatives.

### Criteria for inclusion and exclusion of the sample

Volunteers older than 18 years and of both sexes, who did not meet the criteria for any SUD who had SUD for alcohol and/or tobacco use, or who had SUD related to multiple substances were the participants of the research. The criteria for the diagnosis of SUD were based on the Diagnostic and Statistical Manual of Mental Disorders (DSM-5)<sup>27</sup> To reduce the risk of response bias, those with a score lower than 20 on the Mini-Mental State Examination<sup>28</sup> were excluded and classified as having cognitive deficit, as it may interfere in the proper application of the instruments used, also volunteers with a current psychotic outbreak or who were under the effect of drugs at the time of collection.

### Procedure and instruments

Data collection began after the signing of the informed consent form (ICF), carried out through an individual interview with an average duration of fifty minutes in an air-conditioned room. The instruments used were: socio-demographic questionnaire; Mini-Mental State Examination, in order to assess any presence of cognitive deficit<sup>28</sup>; Emotion Regulation Profile (ERP), to investigate adaptive and maladaptive, functional and dysfunctional emotion regulation strategies<sup>29</sup>; The Trail Making Test, part B, used to measure cognitive flexibility<sup>30</sup> Stroop test, part C, to check inhibitory control; The Digits subtest in the WISC-III to evaluate working memory<sup>31</sup>; I -Structured Clinical Interview for DSM-IV, to track psychiatric disorders and the risk of suicide<sup>32</sup>. Nine distinct classes of SUD (alcohol, tobacco, cannabis, hallucinogens, inhalants, opioids, stimulants, amphetamines and sedatives, hypnotics and anxiolytics) were investigated based on criteria established by the Diagnostic and Mental Disorders Statistics-5 (DSM-5), through a clinical interview. DSM-5 classifies SUD according to severity on three levels: mild, moderate and severe.

### Statistical analyzes

Descriptive and inferential statistics were performed using the SPSS – Statistical Package for Social Sciences, version 22 (IBM, SPSS, version 22). Descriptive statistics were calculated from frequencies for sociodemographic variables according to the groups. Association was made among sociodemographic variables by means of the Chi-square test ( $X^2$ ).

In the analysis of the executive functions, the mean time for the execution of the inhibitory control and cognitive flexibility tests and the sum of the scores obtained in the working memory tests were considered. As it was a cross-sectional study, the means of these tests were compared among the groups studied, rather than comparing them to the normative data, which are intended for clinical case studies, in which the clinical result is compared to the normative data of the population. In this case, one-way ANOVA was used to compare the executive functions among the three groups, followed by the Bonferroni test as post hoc.

Emotion regulation was analyzed considering the factors of the questionnaire, the dysfunctional, functional, maladaptive and adaptive regulation. One-way ANOVA was used to evaluate the difference among the groups in the type of strategy used, and then the Bonferroni Post Hoc test was used to analyze the comparisons of the groups in pairs. Bonferroni correlations were performed.

In the analysis of the executive functions and emotion regulation of the groups, Pearson's correlation tests were applied. In this case, the means of time in the tests of inhibitory control and cognitive flexibility, the sum of the scores obtained in the tests of working memory and the factors of the emotional regulation scale were considered.

## Ethical aspects

This research followed the guidelines of the National Health Council, Resolution No. 466, of December 12, 2012, on research involving human beings, being approved by the Ethics Committee, CAAE nº 62521916.6.0000.5208.

## RESULTS

### Sample characteristics

The sample consisted of 130 participants, divided into three groups as described in the method. The mean age of the groups was 27 years ( $SD \pm 11$ ), 36 ( $SD \pm 11$ ) and 33 ( $SD \pm 8$ ), respectively. The other sociodemographic characteristics are described in Table 1.

### Performance in executive functions by group

The EF presented statistically significant results when compared to the performance of groups, as shown in Table 2. Worse performance was observed in the groups with SUD (group 02 and group 03) in all tests when compared to non-SUD (group 01). Among the groups with SUD, group 03 had the worst result.

One-way ANOVA was used, which detected that there are significant differences among all groups in relation to the inhibitory control, STROOP C [ $F(2,127) = 6.64, p = 0.05$ ]; in the WM, direct order digit span task (DOT) [ $F(2,127) = 5.64, 0.05$ ], indirect order digit span task (IOT) [ $F(2,127) = 10.37, p < 0.05$ ], and in the cognitive flexibility, part B of Trail Making Test (TMTB) [ $F(2,66) = 8.6, p < 0.05$ ].

Regarding the inhibitory control (IC), significant results were observed in which the groups with SUD (groups 02 and 03) performed worse in the STROOP C test compared to group 01. Group 01 was faster in solving this test with 10.57 and 14.37 seconds less than groups 02 and 03, respectively.

In direct and indirect working memory tests, group 1 showed better performance than participants with SUD (group 02 and group 03). In both tests the score of group 01 was higher, being in the DOT with 1.66 and 1.92 and in the IOT with 2.03 and 2.33 points more than the groups 02 and 03, respectively.

Regarding cognitive flexibility (CF), the best performance was in group 01, through the post hoc analysis of the TMT B test. Group 1 was faster than groups 02 and 03 with 63.08 and 88.87 seconds less to complete the task, respectively.

**Table 1.** Characterization of the sample

	Group 01	Group 02	Group 03	$\chi^2$	P
	Non-SUD Fr (%)	SUD – alcohol and/or tobacco Fr (%)	TUS – poly substance users Fr (%)		
Gender					
Male	22 (31,4)	34 (48,6)	14 (20)	13,50	0,001*
Female					
Marital status	38 (63,3)	17 (28,3)	5 (8,3)		
No relationship	47 (47%)	38 (38%)	15 (15%)	6,41	0,379
In a relationship	13 (43,5%)	13 (43,5%)	4 (13%)		
Religion					
Catholic	33 (46,5)	32 (45,1)	6 (8,5)	9,53	0,146
Evangelical	16 (51,6)	7 (22,6)	8 (25,8)		
No religion	11 (40,7)	11 (40,7)	5 (18,5)		
Another religion	0 (0)	1 (100)	0 (0)		
Occupation					
Student	42 (75)	12 (23,5)	2 (3,6)	38,20	0,001*
Employed	11 (35,5)	15 (48,4)	5 (16,1)		
Unemployed	5 (16,1)	17 (54,8)	9 (29)		
Retired	2 (25)	4 (50)	2 (25)		
Informal work	0 (0)	3 (75)	1 (25)		
Formal education in years					
Up to 9 years	7 (16,8)	22 (52,3)	13 (30,9)	29,47	0,001*
Between 10 and 13 years	11 (44)	11 (44)	3 (16)		
More than 14 years	42 (53)	18 (25,3)	11 (15,4)		

\*  $p < 0,05$

## Emotional regulation in groups

Regarding the use of ER strategies (Table 3), a tendency of the sample to use more adaptive strategies elicited in scenarios that evoke positive emotions was evidenced. Regarding the use of dysfunctional and maladaptive strategies, the groups with SUD (group 02 and group 03) showed a higher frequency in the use of these strategies than the non-SUD group (group 01). Group 03 had the worst ER.

In the dysfunctional regulation strategy, significant differences were found between groups 01 and 02 and between groups 01 and 03. The group 02 obtained a difference of 1.2 in the score indicating greater use of dysfunctional regulation than group 1, while Group 03 presented a difference of 1.4 in the score of this factor, indicating greater use of this strategy than group 1. When compared to group 01, group 02 showed a difference of 0.7 in the score of Maladaptive Regulation and group 03 a difference of 1.2, showing the greater use of this strategy by users with SUD when compared to non-SUD.

## Executive functions and emotion regulation in drug users

The EF and ER were significantly correlated in the groups without SUD (group 01) and with SUD by alcohol and/or tobacco (group 02), however it was not observed in group 03.

In group 01, it was observed (Table 4) that the use of dysfunctional ER strategies presented weak negative correlations with the IC (STROOP C) and CF (TMTB), with coefficients -0.36 and -0.37, respectively. This correlation indicates that when the performance in IC and CF increases, the use of dysfunctional ER strategies decreases or that when the use of these ER strategies increases, performance in IC and CF decreases.

Significant results were observed in group 02, (direct and indirect order) WM and the maladaptive ER strategy, according to Table 5. There were two significant negative correlations, with a variance of approximately 14% in both cases. This indicates that when one of the variables increases, the other decreases, that is, if WM is more preserved, there is less use of maladaptive ER strategy, or, if there is more use of maladaptive ER, the performance of WM will be lower.

**Table 2.** Comparisons of group performance in executive function tests

	Group 01 Non-SUD AV (SD)	Group 02 SUD – alcohol and/or tobacco AV (SD)	Group 03 SUD – poly substance users AV (SD)	F	P < 0,05
STROOP C	26,53 (14,78)	37,1 (22,42)	40,9 (17,77)	6,64	0,002**
DOT	9,72 (2,91)	8,06 (3,22)	7,8 (2,14)	5,64	0,004**
IOT	5,93 (2,64)	3,9 (2,7)	3,6 (2,54)	10,37	0,001**
TMT.B	98,93 (83,38)	162,01 (113,32)	187,8 (102,88)	8,61	0,001**

\* p < 0,05; \*\* p < 0,01; AV: average; SD: standard deviation; Md: median; DOT: direct order digit span task; IOT: indirect order digit span task; TMT.B: Trail Making Test.

**Table 3.** Frequency of the strategies of emotion regulation used by the groups

	Group 01 Non-SUD AV (SD)	Group 02 SUD – alcohol and/or tobacco AV (SD)	Group 03 SUD – poly substance users AV (SD)	F	P < 0,01
Dysfunctional regulation	2,3 (0,91)	3,5 (1,29)	3,6 (1,41)	17,7	0,000**
Functional regulation	4,1 (0,9)	4,2 (0,86)	4,3 (0,73)	0,58	0,773
Maladaptive regulation	2,6 (1,08)	3,3 (1,32)	3,5 (1,39)	7,24	0,001**
Adaptive regulation	5 (0,77)	5,06 (0,86)	4,7 (0,97)	1,09	0,337

**Table 4.** Correlation matrix of executive functions, emotion regulation strategies and group 01

	Dysfunctional regulation	Functional regulation	Maladaptive regulation	Adaptive regulation
STROOP C	-0,36**	0,19	0,26*	0,12
DOT	0,2	-0,07	-0,32	0,06
IOT	0,25	-0,27*	-0,21	-0,02
TMT.B	-0,37**	0,24	0,12	0,05

\* p < 0,05; \*\* p < 0,01; AV: average; SD: standard deviation; Md: median; DOT: direct order digit span task; IOT: indirect order digit span task; TMT.B: Trail Making Test.

**Table 5.** Matrix of correlation of executive functions, strategies of emotion regulation and consumption of licit substances

	Dysfunctional regulation	Functional regulation	Maladaptive regulation	Adaptive regulation
STROOP C	0,09	0,1	0,23	0,14
DDP	-0,00	-0,09	-0,38*	-0,11
DIP	-0,06	-0,06	-0,37*	-0,12
TMT.B	0,18	-0,00	0,22	-0,00

\*  $p < 0,05$ ; AV: average; SD: standard deviation; Md: median; DOT: direct order digit span task; IOT: indirect order digit span task; TMT.B: Trail Making Test.

## DISCUSSION

The results of this research point out that substance use disorder (SUD), executive functions (EF) and emotional regulation (ER) are correlated with each other, corroborating with previous research<sup>33-35</sup>. It was observed that people with SUD had worse performance in EF and more use of dysfunctional and maladaptive ER strategies when compared to people without SUD, confirming previous results<sup>3,7,8,15,16,36</sup>.

Participants with SUD (group 02 and group 03) showed impairments in EF when compared to those without SUD (group 01), with polysubstance users (group 03) having the worst performance. In this sense, researchers verified that alcohol consumption resulted in memory damage, losses in visual perception, lower problem-solving capacity and less mental flexibility<sup>37</sup> and even the social drinkers showed signs of EF alterations<sup>38</sup>. In another study, polysubstance users presented generalized deficits in EF, such as WM, inhibition, cognitive flexibility, self-regulation and decision making<sup>9</sup>. In addition, polysubstance users, when compared to people with SUD of only one substance, presented worse prognosis, earlier onset of consumption, higher rates of treatment abandonment<sup>39</sup> and higher prevalence of psychiatric comorbidities<sup>40</sup>.

Emotional regulation was more frequent in all groups in the use of adaptive strategies, which are related to contexts that evoke positive emotions, and the use of these strategies indicates a tendency in the ability to deal with positive emotions. Despite the evident consumption of drugs in celebrations, festivities and in the seek for pleasure, it is the negative emotion that is associated with relapses, the desire to consume, the attention focused on signs related to consumption and the greater probability of using substances as a mechanism to face problems<sup>41</sup>. These findings support the negative reinforcement model of dependence<sup>42</sup>, where substance use occurs in order to avoid negative affective states caused by drug absence.

It was found that the use of maladaptive and dysfunctional strategies increased in relation to the groups studied, in which group 01 had the least use and group 03 the most use of these strategies. Significant results of emotional impairment were observed in relation to SUD

(group 02 and group 03), and the polysubstance users (group 03), again, showed worse results. ER difficulties, such as limited access to strategies and suppression of thinking, are related to the negative effect of craving<sup>19</sup>. Alcohol users presented greater problems with ER in comparison to social users<sup>43</sup>. Polysubstance users with difficulty in ER were related to early drug use, injectable use and more serious problems of dependence<sup>44</sup>. On the other hand, the use of effective ER strategies was associated with lower drug use in a sample of cocaine users being treated<sup>45</sup>. In this scenario, the inability to regulate emotions makes it difficult to change behavior<sup>46</sup>, which may help to explain the tendency to continue using drugs even in the face of known negative results<sup>47</sup>.

Maladaptive ER and WM are correlated with alcohol and/or tobacco use in this sample. As EF are made up of three related and independent nuclei<sup>1</sup> it is feasible that only the working memory is significantly related to another variable. Previous research corroborates the significant results between WM and ER<sup>22,48</sup>, confirm the losses of alcohol consumption in ER<sup>16</sup> and in the WM<sup>49</sup> and ratify the correlation among WM, ER and alcohol use disorder<sup>33</sup> and cigarette smoking<sup>18</sup>. It is important to note that the higher the doses of alcohol consumption, the lower the performance in the WM and the lower the capacity to manage consumption<sup>49</sup>. In addition, the positive and rewarding effects of alcohol are associated with greater propensity to remember these pleasant stimuli related to consumption, which may influence their drinking behavior<sup>50</sup>. However, poor performance in the WM makes it harder for people to keep in mind why they are drinking<sup>49</sup> which alerts the behavior of continuing to drink automatically, exacerbating the challenge of inhibiting consumption or of having a moderate use.

ER plays a crucial role in the development, severity, treatment and prognosis of SUD, and cognitive deficits also negatively impact SUD<sup>51</sup>. A promising approach in the treatment of addiction is mindfulness, which helps people with SUD to improve behavioral self-control through better regulation of emotions<sup>52</sup>. Interventions based on mindfulness, when compared to traditional interventions, resulted in a significantly lower risk of relapse in substance use and excessive alcohol consumption. Mindfulness acts as a tool that helps to strengthen the ability to observe and deal

with the discomfort associated with the desire or negative affect, generating an impact on the control of substance-consuming behavior and achieving positive and long-term results in the treatment of SUD<sup>53</sup>.

Scientific support which base the importance of interventions in emotion regulation and in the three nuclei of executive functions, inhibitory control, working memory and cognitive flexibility are listed. First, in the absence of an appropriate IC, the SUD easily perpetuates itself in a vicious cycle of abstinence, craving, compulsion, intoxication, and relapse<sup>54</sup>. Second, a hallmark of successful ER is the ability to inhibit behavioral responses such as habits and impulses that are incompatible with personal goals. Third, WM supports the mental representation of the goals and the means of achieving them, supporting proactive forms of ER, allowing individuals to resist tempting stimuli related to substance use. The preserved WM allows recall of the goals which induces behaviors consistent with these goals, while the limited WM increases the occurrence of automatic and impulsive actions. Fourth, cognitive flexibility provides the ability to change behaviors that, while aligned with goals, are not compatible with the user's abilities and possibilities<sup>55</sup>.

Despite the losses in EF and ER related to long-term drug use, the present research is concluded with a motivating perspective. First, the ER is capable of lifelong changes, because it has continuous development<sup>48</sup>, so when there are changes in a person's life context and different forms of coping with everyday situations are required, these new experiences play a primordial role and allow ER processes to be shaped<sup>56</sup>. Second, neuroimaging research supports the hypothesis that people with SUD can recruit mechanisms of inhibitory control mediated by the prefrontal cortex to suppress drug craving<sup>57,58</sup> and these mechanisms of resistance to consumption suggest a significant degree of cognitive flexibility<sup>59</sup>.

The results of this research provide an updated picture of the reality of consumption, which consists of the exclusive use of alcohol, associated or not with cigarettes, and of polysubstance users, including at least one illicit substance, and of their emotional and cognitive impairments. This study described correlations between EF, ER and SUD, however, because it is a cross-sectional study, there are no causal inferences.

The limitations of this study focus on: a) the small number of users with disorders due to the use of polysubstances, including illicit drugs; b) the difference in the variables of age and years of schooling among the groups; c) and because there was no control over the variables of substance use time and psychiatric comorbidities. With regard to the reduced number of the group of polysubstance users, it is noteworthy that the data collection involved all users with SUD of polysubstances who attended the two CAPSads

weekly during the data collection period, who were willing and able to participate in the study. Regarding the limitation of schooling, to minimize the interference of this variable, it was decided to include only volunteers who obtained a score equal to or greater than twenty points in the Mini-Mental State Examination instrument, so as to exclude those with cognitive deficits. It is suggested that future research expand the sample and carry out longitudinal studies, which can deepen the correlations obtained in this study.

## CONCLUSION

This study supports the idea that executive functions (EF), emotional regulation (ER) and substance use disorder (TUS) are related. Participants with SUD had lower performance in EF and worse ER when compared to those without SUD. Volunteers with SUD related to polysubstances (including illicit substances) were those who exhibited the greatest damage. Worst performance in WM and higher maladaptive ER strategies are observed in people with SUD in comparison to those without SUD.

## INDIVIDUAL CONTRIBUTIONS

All authors contributed significantly to the conceiving of the study, methodological approach, analysis and interpretation of the data, as well as in the elaboration of the article, revision of the content and approved the final version to be published.

## CONFLICT OF INTERESTS

The authors report no conflicts of interest.

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