MOCA AS A COMPLEMENTARY TEST OF TRAIL MAKING TEST TO EVALUATE COGNITIVE IMPAIRMENTS IN CHRONIC COCAINE/CRACK USERS

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Resumo:
Existem poucos testes validados para avaliar prejuízos cognitivos em usuários de cocaína/crack, sendo estes restritos a poucos domínios. O *Montreal Cognitive Assessment* (MoCA) é um teste que avalia múltiplos prejuízos cognitivos, validado, por exemplo, para o diagnóstico de demência, e doença de Alzheimer, mas não para usuários de cocaína/crack. Nós comparamos o desempenho de usuários crônicos de cocaína/crack com indivíduos saudáveis no teste MoCA. Nós também avaliamos o desempenho destes indivíduos no teste *Trail Making Test* (TMT) para comparar os resultados. Sujeitos controles e usuários eram ambos do sexo masculino e adultos, com pelo menos 10 anos de escolaridade (para evitar falsos erros cognitivos). No teste MoCA os usuários de cocaína/crack apresentaram escores inferiores aos controles. No TMT (A, B e B-A) também. Esses resultados revelaram prejuízos cognitivos, como, por exemplo, na linguagem e memória dos usuários. Porém, a correlação de escores entre os testes MoCA e TMT foi evidenciada somente no grupo controle, sugerindo não só a diferença, mas outros importantes resultados obtidos com a realização de ambos os testes, de modo a garantir um rastreamento mais completo e múltiplo de prejuízos cognitivos. Portanto, nós sugerimos o uso do MoCA como um teste complementar ao TMT para avaliar prejuízos cognitivos em usuários crônicos de cocaína/crack.
Palavras-chave: *Montreal Cognitive Assessment*; TMT; abuso de drogas.

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Abstract:
There are few validated tests to measure cognitive impairments in cocaine/crack users; these tests are restricted to single/few domains. The Montreal Cognitive Assessment (MoCA) test evaluates multiple cognitive impairments and is valid for dementia, and Alzheimer's disease diagnosis, for example, but not for cocaine/crack users. We compared the performance of chronic cocaine/crack users and healthy individuals in the MoCA test. We also performed the Trail Making Test (TMT) to compare the results. Controls and cocaine/crack users groups were both formed by adult males, with at least 10 years of schooling (to eliminate false cognitive errors). In the MoCA test, cocaine/crack users had lower scores than control subjects. In TMT (A, B, and B-A), they also performed worse than controls. These results revealed cognitive impairments, such as on language, memory, and flexibility in cocaine/crack users. However, a correlation between MoCA and TMT scores was only evidenced in control group; not for cocaine/crack users. This suggests that different and important results could be obtained from both tests, for a more complete and multiple screening on cognitive impairments. Therefore, we suggest the use of MoCA as a complementary test of TMT to evaluate cognitive impairments in chronic cocaine/crack users.
Keywords: Montreal Cognitive Assessment; TMT; Drug abuse.

1. INTRODUCTION

Cocaine/crack abuse is a major worldwide health problem (Richards et al. , 2016). They are the most commonly used illicit drugs among those seeking care in Emergency Departments or drug detoxification centers (Dinis-Oliveira, 2015). Cocaine in powdered form, inhaled, intravenously injected or smoked form (crack) induces several psychiatric (behavioral and brain) and cardiovascular impairments (D'Avila et al. , 2016, Guindalini et al. , 2006). Users routinely present hyperactivity, paranoia, hallucinations, aggressiveness, exacerbation of psychiatric disorders, and suicidal and homicidal tendency (Laranjeira et al. , 2001). Cocaine/crack can also induce severe cognitive impairments, including on planning, work memory, and flexibility aspects (Madoz-Gurpide et al. , 2011). Thus, users are frequently socio-economically marginalized, with elevated risks for morbidity, mortality and crime involvement, resulting in extensive burdens (Fischer et al. , 2015).

Unfortunately, there are few validated tests to measure cognitive impairments in cocaine/crack users; these tests are restricted to a single or few domains. The Trail Making Test (TMT) screens for cognitive abilities such as processing speed,

working memory, and mental flexibility (Kalapatapu et al. , 2011). It is considerate efficient to detect cognitive impairment associated with elderly, dementia, and Alzheimer's disease (Cahn et al. , 1995, Kalapatapu, Vadhan, 2011). TMT Part A has been used for cognitive screening such as psychomotor speed in cocaine users (Beatty et al. , 1995, Kalapatapu, Vadhan, 2011).

The Montreal Cognitive Assessment (MoCA) test is a stand-alone cognitive screening tool with superior sensitivity (Nasreddine et al. , 2005). It covers multiple important cognitive domains. The six different cognitive domains include short-term memory; visuospatial abilities; executive functioning; attention, concentration, and working memory; language; and orientation to time and place (Coen et al. , 2016). The MoCA test is valid for several disorders and specific conditions diagnoses, such as dementia, Alzheimer's disease, cognitive disorders of vascular origin, cerebral tumor metastases, brain tumors, Huntington's disease, and Parkinson's disease (Davis et al. , 2015, Hoops et al. , 2009, Olson et al. , 2008), but not for cocaine/crack users. Thus, knowing that MoCA test is considered a more robust and complete cognitive test than TMT, and that there are no studies evaluating the MoCA test performance of cocaine/crack users, we studied this context. Chronic cocaine/crack users and healthy individuals were evaluated for the MoCA test and the TMT to compare the results. The use of the MoCA test might reveal a more complete and multiple screening of cognitive impairments in chronic cocaine/crack users.

2. MATERIALS AND METHODS

2.1. Ethics Statement

This study was performed in strict accordance with the recommendations of the Code of Ethics of the World Medical Association (Declaration of Helsinki). The protocol was approved by the Committee on the Ethics in Research of the Paulista University, Brazil (Permit Number: 38139714.3.0000.5512). The subjects of the study were informed of the purposes of the research. The subjects signed a term assuming that they accepted participating of this research. The subjects in this manuscript have given written informed consent to publish these case details.

2.2.   Subjects, groups and tests

The present study compared the performance of chronic cocaine/crack users and healthy individuals in the MoCA test for cognitive evaluation. We also performed the TMT to compare the results. Controls (n = 23) and cocaine/crack users (n = 22) groups were both formed by adult males, 18-60 years old, with at least 10 years of schooling. The tests were only performed in individuals with high levels of education to eliminate false cognitive errors. Controls were people without history of drug abuse and/or psychiatric/neurologic disorders. Users were people with chronic cocaine and/or crack abuse, at least four years. These users were admitted in Hospitals and Clinics of Sao Paulo and Bahia (Brazil) and were in the rehabilitation period. For the tests, users should be at least one week without drugs use.

Each subject answered (1) a basic questionnaire with personal identification, history of drug abuse, and comorbidities, as well as (2) MoCA test (Nasreddine, Phillips, 2005), and (3) TMT (Sanchez-Cubillo et al. , 2009) in a single day. The questionnaire collected users' information, such as age, years of schooling, years using cocaine/crack, overdoses, associated pathologies, and number of rehab admissions.

The MoCA is a 30-point test. The short-term memory recall task (5 points) involves two learning trials of five nouns and delayed recall after approximately 5 minutes. Visuospatial abilities are assessed using a clock-drawing task (3 points) and a three-dimensional cube copy (1 point). Multiple aspects of executive functions are assessed using an alternation task adapted from the Trail Making B task (1 point), a phonemic fluency task (1 point), and a two-item verbal abstraction task (2 points). Attention, concentration, and working memory are evaluated using a sustained attention task (target detection using tapping; 1 point), a serial subtraction task (3 points), and digits forward and backward (1 point each). Language is assessed using a three-item confrontation naming task with low-familiarity animals (lion, camel, rhinoceros; 3 points), repetition of two syntactically complex sentences (2 points), and the aforementioned fluency task. Finally, orientation to time and place is evaluated (6 points) (Nasreddine, Phillips, 2005). The maximal score for MoCA test is 30. Using a cutoff score 26, MoCA detect 90% of mild cognitive impairment, being considered a high sensitivity cognitive screening tool (Freitas et al. , 2013, Nasreddine, Phillips, 2005).

The TMT consists of two parts. The TMT A assesses psychomotor speed and simple attention; participants use a pencil to connect a series of encircled numbers in numerical order. The TMT B assesses alternating attention and cognitive flexibility; participants use a pencil to connect 25 encircled numbers and letters in numerical and alphabetical order, alternating between the numbers and letters (Kalapatapu, Vadhan, 2011). We also evaluated a TMT derived analysis: TMT B-A, which removes the speed component from the test evaluation (Perianez et al. , 2007).

2.3.   Statistical analysis

Normality was verified by Shapiro Wilk's test and by Q-Q Plot inspection. If data weren't normally distributed, transformation was applied. Homogeneity of variances was verified by Levene's test for equality of variances. If there wasn't homogeneity of variances, equal variances were not assumed for t statistics. Outliers were detected by inspection of a box-plot. Independent-samples t-tests were performed to compare data of two groups. Unless otherwise stated, data are reported as mean ± standard deviation. The partial eta squared, a measure of effect size, and 95% confidence interval of the difference were also reported for each t test. For correlation analysis, a Pearson's product-moment correlation was run to assess the relationship between the variables in study, and bootstrapped 95% confidence intervals were calculated. For all analysis, results were considered significant at $p < 0.05$ (Field, 2013, Richardson, 2011).

3. RESULTS

We evaluated 45 male subjects with at least 10 years of schooling; 23 controls and 22 cocaine/crack users. An independent-samples t-test was run to determine if there were differences in age between drug addicts and control subjects. There were two outliers in the data. Age for each group was normally distributed, as assessed by Shapiro-Wilk's test ($p > 0.05$), and there was homogeneity of variances, as assessed by Levene's test for equality of variances ($p = 0.670$). Cocaine/crack users were older (34.00 ± 7.52) than control subjects (27.65 ± 7.44), with a statistically significant difference of 6.35 years (95% CI, 1.85 to 10.85), $t_{(43)} = 2.845$, $p = 0.007$. The partial eta squared, a

measure of the proportion of the variation in age that is associated with membership of the different groups, was of large size ($\eta^2 = 0.158$).

The years of schooling were 12.00±0.00 for controls and 11.81±0.59 for cocaine/crack users. Table 1 shows data collected from users in the basic questionnaire with personal identification, history of drug abuse, and comorbidities. The average years using cocaine/crack was 16.19±8.10. The average number of rehab admissions for users was 4.95±4.59. Subjects of control group did not report any pathology or relevant disease.

Table 1. Questionnaire with personal identification of cocaine/crack users, history of drug abuse, and comorbidities

User	Age	Years of schooling	Years using cocaine/ crack	Overdoses	Associated pathologies	Number of rehab admissions
1	35	10	11	Deny	No	3
2	34	12	4	Deny	No	3
3	52	12	29	Yes	No	18
4	19	12	7	Deny	No	4
5	42	12	7	Deny	No	4
6	37	12	20	Deny	No	1
7	39	10	30	Deny	No	6
8	37	12	19	Deny	No	12
9	26	12	5	Deny	No	2
10	34	12	15	Yes	No	1
11	24	12	6	Deny	No	2
12	36	12	17	Deny	No	4
13	32	12	17	Deny	No	7
14	31	12	16	Deny	No	3
15	34	12	16	Deny	HIV+ and Syphilis	1
16	48	12	34	Yes	No	2
17	34	12	19	Deny	No	15
18	35	12	20	Deny	No	5
19	26	12	8	Deny	HIV+	2
20	36	12	20	Yes	No	6
21	32	12	17	Deny	HIV+	7
22	25	12	7	Deny	No	1

MoCA scores for each group weren't normally distributed, as assessed by Shapiro-Wilk's test ($p < 0.05$), so a "reflect and square root" transformation was

applied to convert moderately negatively skewed data to normality. An independent-samples t-test was run to determine if there were differences in MoCA scores between cocaine/crack users and control subjects. There were three outliers in the data, as assessed by inspection of a box-plot. There was homogeneity of variances for transformed MoCA scores, as assessed by Levene's test for equality of variances (p = 0.203). Cocaine/crack users had lower scores (21.27 ± 3.79) than control subjects (26.95 ± 1.72), with a statistically significant difference of 5.42 points (95% CI, 3.67 to 7.18), $t_{(43)}$ = -7.012, p < 0.001. The partial eta squared was of large size (η^2 = 0.533). Results of MoCA scores are shown in Figure 1.
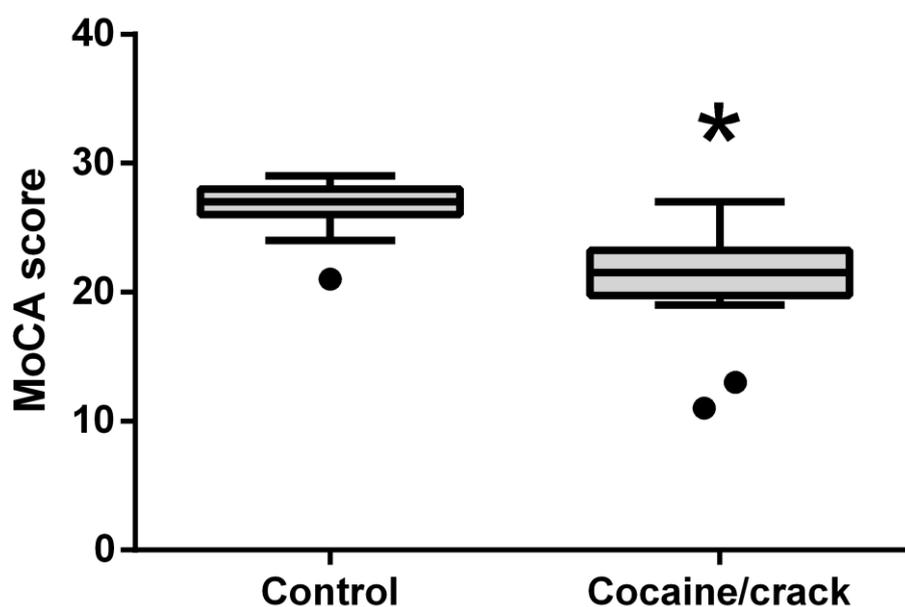
Fig 1 - **MoCA test.** Scores of the Montreal Cognitive Assessment (MoCA) test of controls and cocaine/crack users (Box-plots). All subjects were adult males, with at least 10 years of schooling. Controls were people without history of drug abuse and/or psychiatric/neurologic disorders (n = 23). Users were people with at least four years of chronic cocaine and/or crack abuse and in the rehabilitation period (n = 22). Cocaine/crack users had lower scores (21.27 ± 3.79) than control subjects (26.95 ± 1.72), with a statistically significant difference (*) of 5.42 points (95% CI, 3.67 to 7.18), t(43) = -7.012, p < 0.001.

The TMT A assesses psychomotor speed and simple attention. TMT A scores for each group weren't normally distributed, as assessed by Shapiro-Wilk's test (p

< 0.05), so an "inverse" transformation was applied to convert extremely positively skewed data to normality. An independent-samples t-test was run to determine if there were differences in TMT A scores between cocaine/crack users and control subjects. There were four outliers in the data, as assessed by inspection of a boxplot. There was homogeneity of variances for transformed TMT A scores, as assessed by Levene's test for equality of variances (p = 0.286). Cocaine/crack users had higher scores (61.89 ± 67.58) than control subjects (27.19 ± 9.82), with a statistically significant difference of 34.70 seconds (95% CI, 5.98 to 63.42), t(43) = 5.179, p < 0.001. The partial eta squared was of large size (η^2 = 0.384). Results of TMT A are shown in Figure 2A.

The TMT B assesses alternating attention and cognitive flexibility. TMT B scores for each group weren't normally distributed, as assessed by Shapiro-Wilk's test (p < 0.05), so an "inverse" transformation was applied to convert extremely positively skewed data to normality. An independent-samples t-test was run to determine if there were differences in TMT B scores between cocaine/crack users and control subjects. There were two outliers in the data, as assessed by inspection of a boxplot. There was homogeneity of variances for transformed TMT B scores, as assessed by Levene's test for equality of variances (p = 0.984). Cocaine/crack users had higher scores (148.20 ± 129.97) than control subjects (64.24 ± 19.18), with a statistically significant difference of 83.96 seconds (95% CI, 28.72 to 139.21), t(43) = 5.957, p < 0.001. The partial eta squared was of large size (η^2 = 0.452). Results of TMT B are shown in Figure 2B.

We also evaluated a TMT derived analysis: TMT B-A removes the speed component from the test evaluation. TMT B-A scores for each group weren't normally distributed, as assessed by Shapiro-Wilk's test (p < 0.05), so a "square root" transformation was applied to convert moderately positively skewed data to normality. An independent-samples t-test was run to determine if there were differences in TMT B-A scores between cocaine/crack users and control subjects. There was one outlier in the data, as assessed by inspection of a box-plot. There wasn't homogeneity of variances for transformed TMT B-A scores, as assessed by Levene's test for equality of variances (p < 0.001), so equal variances were not assumed for t statistcs. Cocaine/crack users had higher scores (86.31 ± 73.12) than control subjects (37.04 ± 14.76), with a statistically significant difference of 49.27 seconds (95% CI, 17.88 to 80.64), $t_{(43)}$ = -3.366, p = 0.002.

The partial eta squared was of large size (η^2 = 0.209). Results of TMT B-A are shown in Figure 2C.
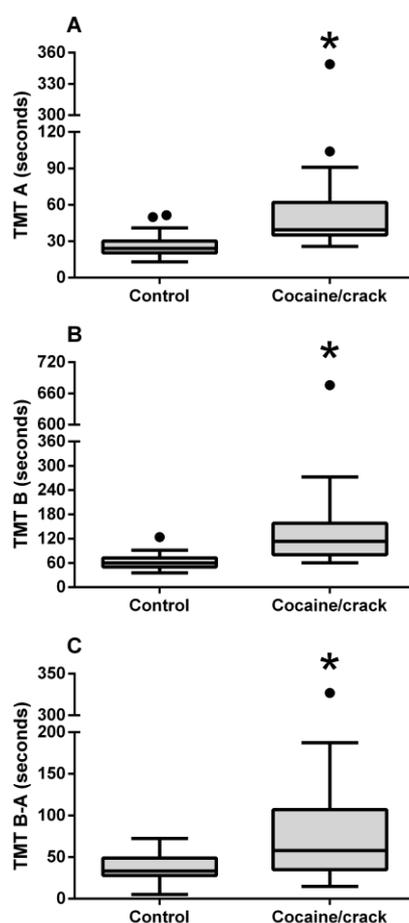
Fig 2 – TMT. Performance of Trail Making Test (TMT) A and B, and derived analysis (B-A) of controls and cocaine/crack users (Box-plots). All subjects were adult males, with at least 10 years of schooling. Controls were people without history of drug abuse and/or psychiatric/neurologic disorders (n = 23). Users were people with at least four years of chronic cocaine and/or crack abuse and in the rehabilitation period (n = 22). For TMT A (A), cocaine/crack users had higher scores (61.89 ± 67.58) than control subjects (27.19 ± 9.82), with a statistically significant difference (*) of 34.70 seconds (95% CI, 5.98 to 63.42), t(43) = 5.179, p < 0.001. For TMT B (B), cocaine/crack users had higher scores (148.20 ± 129.97) than control subjects (64.24 ± 19.18), with a statistically significant difference of 83.96 seconds (95% CI, 28.72 to 139.21), t(43) = 5.957, p < 0.001. For TMT B-A (C), cocaine/crack users had higher scores (86.31 ± 73.12) than control subjects (37.04 ± 14.76), with a statistically significant difference of 49.27 seconds (95% CI, 17.88 to 80.64), t(43) = -3.425, p = 0.001.

Table 2 shows the descriptive analysis of the variables observed: age, MoCA, TMT A and TMT B scores, as well as a TMT derived analysis – TMT B-A, which removes the speed component from the test evaluation.

Table 2 - Descriptive analysis of the variables in study.

Control Group	Mean	SD	95%CI Lower bound	95%CI Upper bound	N	SW
Age	27.65	7.44	24.43	30.87	23	0.071
MoCA	26.95	1.72	25.95	27.44	23	*0.002*
TMT A	27.19	9.82	22.95	31.44	23	*0.014*
TMT B	64.24	19.18	55.94	72.53	23	*0.012*
TMT B-A	37.04	14.76	30.66	43.43	23	0,753
Drug Addicts	Mean	SD	95%CI Lower bound	95%CI Upper bound	N	SW
Age	34.00	7.52	30.67	37.34	22	0.315
MoCA	21.27	3.79	21.52	22.96	22	*0.028*
TMT A	61.89	67.58	31.93	91.86	22	*<0.001*
TMT B	148.20	129.97	90.57	205.83	22	*<0.001*
TMT B-A	86.31	73.12	53.89	118.73	22	*0,001*

95%IC: 95% confidence interval of the mean; *SW*: p values of the Shapiro-Wilk normality test.

A Pearson's product-moment correlation was run to assess the relationship between the variables in study, and bootstrapped 95% confidence intervals were calculated. Only correlation coefficients whose 95% confidence intervals didn't cross zero values were considered (r = 0, no correlation). Significant correlations were observed between variables: MoCA and TMT B-A, and TMT A and TMT B scores, for control subjects; TMT A and TMT B, and TMT B and TMT B-A scores, for cocaine/crack users. Large effect sizes (r ≥ 0.5 or r ≤ -0.5) were observed in all considered correlations. Since preliminary analyses showed that not all variables were normally distributed, and there were outliers in some of them, correlation analysis were performed with transformed and raw data. Conclusions of significance were the same on both situations, although r values may have changed. Table 3 shows the results for untransformed data.

Table 3 - Pearson's product-moment correlation coefficients between participant age, number of rehabilitations, and MoCA, TMT A, TMT B or TMT B-A scores.

Control Group	Age	MoCA	TMT A	TMT B	TMT B-A
MoCA	0.311				
TMT A	0.030	-0.308			
TMT B	0.081	**-0.612****	**0.654****		
TMT B-A	0.086	**-0.591****	0.185	0.864	
Rehabilitation	–	–	–	–	–
Cocaine/crack users	Age	MoCA	TMT A	TMT B	TMT B-A
MoCA	0.077				
TMT A	-0.045	0.041			
TMT B	-0.056	-0.022	**0.917****		
TMT B-A	-0.057	-0.077	0.706**	**0.930****	
Rehabilitation	0.445*	-0.035	0.052	0.044	0.030

*: $p < 0.05$ Pearson's product-moment correlation coefficients; **: $p < 0.01$ Pearson's product-moment correlation coefficients; gray highlights: significant r values whose bootstrapped 95%IC didn't cross zero values.

For control subjects, there was a strong negative correlation between MoCA and TMT B-A scores ($r_{(21)}$ = -0.591, p = 0.003), with TMT B-A scores explaining 35% of the variation in MoCA results (or vice versa). There was also a strong positive correlation between TMT A and TMT B scores ($r_{(21)}$ = 0.654, p = 0.001), with TMT A scores explaining 43% of the variation in TMT B results (or vice versa).

For cocaine/crack users, there was also a strong positive correlation between TMT A and TMT B scores ($r_{(20)}$ = 0.917, p < 0.001), with TMT A scores explaining 84% of the variation in TMT B results (or vice versa). A strong positive correlation between TMT B and TMT B-A scores was also observed ($r_{(20)}$ = 0.930, p < 0.001), with TMT B scores explaining 86.5% of the variation in TMT B-A results (or vice versa).

Among the declared drugs used by those that are addicts, cocaine, crack and marijuana were the most used. Generally, they declared to be on multiple drugs simultaneously. Figure 3 shows the frequency of users per drug.
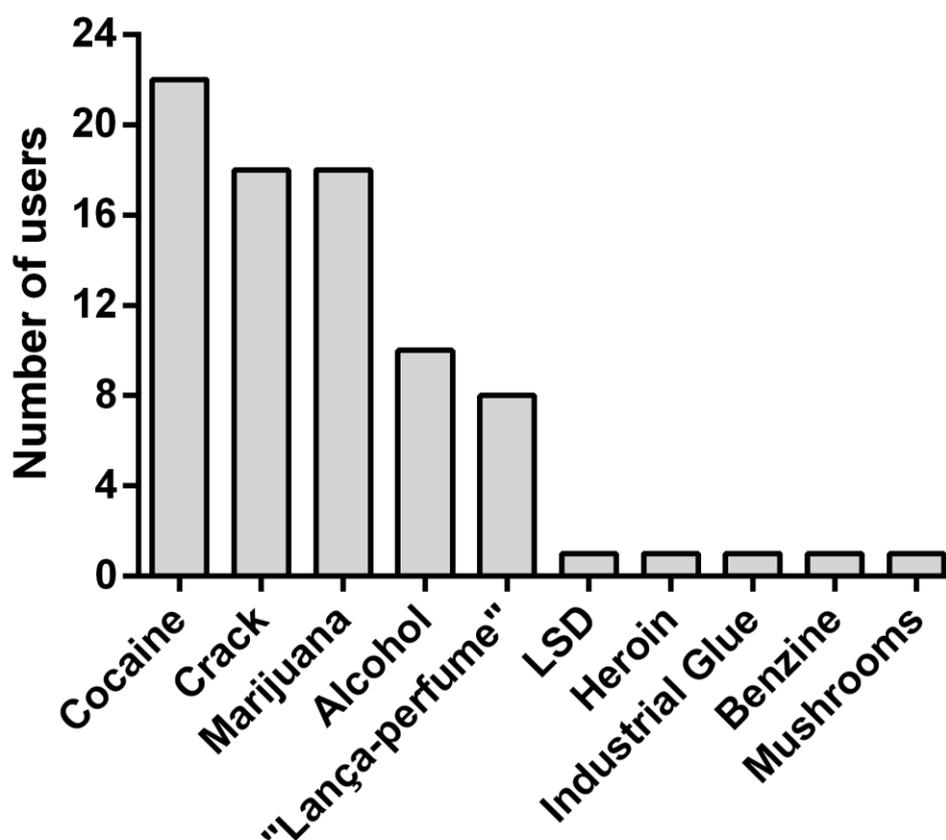
Fig 3 - Drug types. Frequency of users per drug type. Users were people with at least four years of chronic cocaine and/or crack abuse and in the rehabilitation period (n = 22).

4. DISCUSSION

The present findings revealed that cocaine/crack users performed worse than controls for both MoCA test and TMT. In other words, chronic cocaine/crack induced severe cognitive impairments. To our knowledge, this is the first study of MoCA test in cocaine/crack users. There are some studies for cocaine/crack users in TMT. Horton and colleagues evaluated cocaine/crack users analyzing several variables, such as sex, age, ethnicity and education (Horton and Roberts, 2001, 2002, 2005). Specifically, cocaine-related impairments have been found for cognitive abilities such as psychomotor speed, as measured by TMT Part A (Beatty, Katzung, 1995, Kalapatapu, Vadhan, 2011). Besides the impairment in TMT A, we also showed impairment in TMT B, revealing problems in psychomotor speed, simple attention, alternating attention, and cognitive flexibility. Thus, our present results in MoCA test similar as those found in TMT seems to validate the

use of MoCA test for studies screening cognitive impairments in cocaine/crack users.

The fact that control group presented scores higher than 26, contribute to certify the reliability of the MoCA test presently applied, because scoring 26 or more is considered a normal score (Nasreddine, Phillips, 2005). After all, using a cutoff score 26, MoCA detect 90% of mild cognitive impairment, being considered a high sensitivity cognitive screening tool (Freitas, Simoes, 2013, Nasreddine, Phillips, 2005).

In the MoCA test, memory tasks are performed using several words and longer interval of time preceding the evocation. Moreover, tasks evaluating executive functions demands more language skills, needs complex visuospatial processing, attention, concentration, and working memory of the evaluated subject (Nasreddine, Phillips, 2005). Thus, MoCA is considered an adequate and useful test for screening cognitive deficits in individuals with high levels of education (Luis et al. , 2009, Nasreddine, Phillips, 2005, Trenkle et al. , 2007). Presently, MoCA test evaluation revealed multiple cognitive impairments in cocaine/crack users, such as short-term memory; visuospatial abilities; executive functioning; attention, concentration, and working memory; language; and orientation to time and place.

Talking about cognition and cocaine/crack users, attention, memory, decision-making, and troubleshooting are frequent affected domains (Aharonovich et al. , 2006, Cunha et al. , 2004). Chronic cocaine users increase the endurance in errors, present poor inhibitory control and low ability to learn from mistakes, as well as failure in motivational skills (Block et al. , 2002, Madoz-Gurpide, Blasco-Fontecilla, 2011). These peculiarities usually results in social marginalization of users. Other deficits, such as in processing information, attention, speed of motor response, and verbal and visual memory are also common in cocaine users (Goldstein et al. , 2007, Jovanovski et al. , 2005). Behavioral impairments are usually associated with prefrontal cortex, temporal lobes, and limbic system morphological, functional and neurochemical damages (Bartzokis et al. , 2000, Liu et al. , 1998).

Reports indicate that cocaine/crack users also commonly use other drugs of abuse, such as marijuana and alcohol (Ferreira Filho et al. , 2003, van der Meer Sanchez and Nappo, 2002). Moreover, they use prescription drugs for clinical

treatment, such as sedatives (Dutra et al. , 2008). Marijuana, alcohol, and prescription drugs may interfere with cognitive performance (Dutra, Stathopoulou, 2008, Preller et al. , 2014). In the present study, it is reasonable that several cocaine/crack subjects have used other substances that may change the cognitive patterns. However, this is an observatory study, which makes it almost impossible to exclude these variables (such as marijuana and alcohol). We think that given the long period of chronic use of cocaine/crack (average of 16.19 years) and the severity of the impairments that these drugs do when compared with other drugs, the cognitive impairments presently found may be mainly due to cocaine/crack abuse.

Besides use of other drugs of abuse than cocaine and crack, there are other possible interference factors in the cognitive evaluation. Cocaine increases the risk of cardioembolic and ischemia strokes, and central nervous system vasculitis (Heesch et al. , 2000, Zimmerman, 2012). However, cocaine/crack users presently evaluated did not report any cardioembolic stroke or ischemia, although four of them reported overdoses. Even if these four subjects were removed from the statistical analysis, cocaine/crack still induced cognitive impairments in MoCA test (data not shown). Likewise, cocaine/crack abuse is associated with sexual risk behaviors (such as promiscuity), increasing the prevalence of chronic infectious diseases such as human immunodeficiency virus (HIV) and tuberculosis (Fischer, Blanken, 2015). Only three cocaine/crack users reported to be HIV+. HIV can induce brain functional impairments and severe cognitive disabilities (e.g., dementia) (Meade et al. , 2015, Valcour et al. , 2011). Even if these three subjects were removed from the statistical analysis, cocaine/crack still induced cognitive impairments in MoCA test (data not shown). Thus, although there are several additional factors which may interfere with cognitive performance, we think that the present data of MoCA test sustained the severe cognitive impairment in the cocaine/crack users.

Correlation analysis revealed that there was a strong positive correlation between TMT A and TMT B scores, regardless the subjects were for control group or cocaine/crack users. On the other hand, a (negative) correlation between MoCA and TMT B-A scores was only evidenced in control group, suggesting that the higher the score was in MoCA test, the lower the score was in TMT B-A for the same subject, with TMT B-A scores explaining 35% of the variation in MoCA results (r = -0.591, p = 0.003, strong effect). However, there wasn't a

correlation between MoCA and TMT B-A scores for cocaine/crack users (r = -0.077, p = 0.735). This suggests that different and important results could be obtained from both tests, and, therefore, it enhances the importance of evaluating MoCA analysis on these subjects.

5. CONCLUSIONS

In conclusion, cocaine/crack users performed worse than controls for the MoCA test. These results revealed cognitive impairments, such as on language, memory, and flexibility. To our knowledge, this is the first study of the MoCA test specifically for cocaine/crack users. These cocaine/crack users also presented impairments in TMT A, B, and B-A. However, a correlation between MoCA and TMT scores was only evidenced in control group; not for cocaine/crack users. This suggests that different and important results could be obtained from both tests, for a more complete and multiple screening on cognitive impairments. Therefore, we suggest the use MoCA as a complementary test of TMT to evaluate cognitive impairments in chronic cocaine/crack users. The use of the MoCA test might be useful for planning prevention and rehab strategies.

6. CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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