EFFICACY OF COMPUTER-ASSISTED COGNITIVE STIMULATION IN PSYCHIATRIC DISORDERS: CORRELATIONS BETWEEN DIAGNOSIS, TREATMENT AND EVOLUTION OF COGNITIVE SCORES

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EFFICACY OF COMPUTER-ASSISTED COGNITIVE STIMULATION IN PSYCHIATRIC DISORDERS: CORRELATIONS BETWEEN DIAGNOSIS, TREATMENT AND EVOLUTION OF COGNITIVE SCORES (Abstract): This study **aims** to investigate the effectiveness of computer-assisted cognitive stimulation (CACS) in improving cognitive deficits associated with psychiatric disorders. **Materials and methods:** The study evaluated the impact of the CACS intervention on cognitive functions using standardized instruments such as the Mini-Mental State Examination (MMSE) and the Montreal Cognitive Assessment (MoCA). In addition, the influence of diagnosis and demographic variables on the results obtained was analyzed, highlighting significant variations depending on the typology of the psychiatric disorder treated. **Results:** The data indicate considerable improvements in the cognitive domain, with differences between diagnostic groups highlighting the importance of a differentiated approach. **Conclusions:** The results support the need for personalization of interventions and highlight the relevance of assessing qualitative factors in the application of CACS, opening new research directions for optimizing the treatment of psychiatric disorders through cognitive technology.
Keywords: COMPUTER-ASSISTED COGNITIVE STIMULATION (CACS), PSYCHIATRIC DISORDERS, COGNITIVE ASSESSMENT, MMSE, MOCA.

INTRODUCTION

Psychiatric disorders, such as depression and schizophrenia are often associated with profound cognitive deficits, which significantly impact the quality of life of patients. These cognitive impairments not only occur frequently but also vary depending on the type of disorder, the patient's age and the severity of symptoms (1). In particular, the importance of cognitive assessment has been emphasized in the context of neurodegenerative diseases, for example, (2) highlight the essential role of standardized instruments, such as Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA), in identifying cognitive deficits which are sometimes not detectable by conventional clinical assessments.

Non-pharmacological interventions, such as computer assisted cognitive stimulation (CACS) have shown considerable potential in improving these deficits. Recent studies suggest that the effects of CACS may be influenced by factors such as the specific diagnosis, age and intensity of the intervention. (3) and (4) showed that the response to CACS varies depending on the clinical characteristics of the patients and (5) reported moderate improvements in cognitive function, although with notable differences between different psychiatric disorders (6).

These findings highlight the need for personalized interventions, adapting them to the particularities of each patient to maximize cognitive benefits.

Another aspect of interest is the impact of age on the effectiveness of CACS (7) found that age is not always a robust predictor of intervention outcomes, suggesting that variables such as the number of sessions and the severity of initial cognitive deficits may play a more determining role. In this regard, (8) demonstrated that an increased number of CACS sessions is associated with significant improvements in MMSE and MoCA scores, highlighting a positive relationship between the intervention and cognitive performance.

Therefore, analyzing the efficacy of CACS, assessed changes in MMSE and MoCA scores, as well as investigating the influence of diagnosis and other factors (age, number of sessions) on cognitive outcomes, are crucial for the development of personalized and evidence-based therapeutic strategies in the treatment of cognitive deficits associated with psychiatric disorders.

MATERIALS AND METHODS

This study included 92 patients with psychiatric disorders. Inclusion criteria for selecting patients with a confirmed diagnosis of psychiatric disorders who had participated in a minimum of 10 sessions of computerized cognitive stimulation. Exclusion criteria included the presence of major comorbidities that could influence the assessment of cognitive function, the inability to provide informed consent and the existence of severe medical conditions requiring urgent interventions. These patients completed at least 10 sessions of CACS. Diagnoses were numerically coded to facilitate statistical analysis (e.g., 1 - emotionally unstable personality disorder, 2 - bipolar affective disorder - depressive episode, 3 - severe depressive episode - generalized anxiety disorder). In the first table is presented the full list of psychiatric conditions included in the study.

Patients were selected according to the inclusion and exclusion criteria established in the study protocol.

Cognitive function was assessed using the MMSE and MoCA, both before and after CACS intervention. The number of CACS sessions ranged from 3 to 233, depending on the protocol individualized for each patient.

The procedure included an initial assessment of patients using MMSE and MoCA, followed by CACS, with a frequency of 1-2 sessions per week, each session lasting 60 minutes.

After completing the CACS session, patients were re-assessed using the same cognitive scales.

TABLE I.
Psychiatric diagnoses included in the study and numerical coding

Numeric code	Diagnostic
1	Emotionally unstable personality disorder
2	Bipolar affective disorder - depressive episode
3	Severe depressive episode, Generalized anxiety disorder
4	Depressive episode with anxiety elements
5	Severe depressive episode
6	Organic mood disorder
7	Mixed dementia, Recurrent depressive disorder
8	Acute psychotic disorder with schizophrenia symptoms
9	Recurrent depressive disorder, severe current episode
10	Mixed dementia, Recurrent depressive disorder
11	Generalized anxiety disorder, Obsessive-compulsive disorder
12	Severe depressive episode with atypical features
13	Mild cognitive disorder
14	Atypical autism
15	Mixed dementia - mild form
16	Paranoid schizophrenia
17	Attention and activity disorder
18	Dependent personality disorder
19	Recurrent depressive disorder - severe current episode
20	Recurrent depressive disorder - current episode moderate
21	Dementia in early-onset Alzheimer's disease
22	Emotionally unstable personality disorder, Mild depressive episode
23	Generalized anxiety disorder, Depressive episode with atypical features
24	Panic disorder, Mild depressive episode, Mixed dementia
25	Recurrent depressive disorder - current moderate episode with psych cognitive features
26	Severe depressive episode, generalized anxiety disorder, Sleep disorder
27	Recurrent depressive disorder - current moderate episode, Nonorganic insomnia
28	Mild depressive episode, Adjustment disorder
29	Mild cognitive disorder, Anxiety disorder
30	Recurrent depressive disorder
31	Emotionally unstable personality disorder
32	Adjustment disorder, Nonorganic insomnia
33	Mild cognitive disorder, Moderate depressive episode, Paroxysmal anxiety disorder
34	Posttraumatic stress disorder

Numeric code	Diagnostic
35	Recurrent depressive disorder - mild current episode
36	Anxiety disorder, Recurrent depressive disorder - moderate depressive episode
37	Mixed anxiety and depressive disorder
38	Mixed dementia, Organic personality disorder, Severe depressive episode
39	Cognitive disorder, Recurrent depressive disorder, Generalized anxiety disorder
40	Recurrent depressive disorder - severe current episode without psychotic symptoms
41	Recurrent depressive disorder - severe current episode without psychotic symptoms, Generalized anxiety disorder
42	Mild depressive episode, Panic disorder
43	Moderate depressive episode
44	Panic disorder
45	Cognitive disorder, Severe current depressive episode with psychotic symptoms
46	Cyclothymia
47	Bipolar affective disorder - depressive episode, Cognitive disorder
48	Anxiety disorder, Mild depressive episode
49	Sleep disorder
50	Schizophrenia
51	Emotionally unstable personality disorder, Anxiety disorder
52	Cognitive disorder, Chronic organic cerebral disorder
53	Moderated mixed dementia, Moderate depressive episode
54	Moderate depressive episode with anxious - interpretive elements
55	Moderated mixed dementia, Severe depressive episode
56	Late-ons*et al*zheimer's disease dementia
57	Sexual identity disorder, Disturbance of attention and activity
58	Mixed dementia, Recurrent depressive disorder - severe current episode
59	Cognitive disorder
60	Mixed dementia

Statistical analyses included the paired-samples t-test used to compare MMSE and MoCA scores before and after the intervention, to determine whether there was a significant improvement in cognitive function. One-way ANOVA was used to compare differences between diagnostic groups in terms of MMSE and MoCA scores. Pearson correlations were calculated to assess the relationship between age, number of CACS sessions and differences in cognitive scores (ΔMMSE and ΔMoCA).

All personal data of patients were stored and processed in accordance with GDPR regulations. Patients signed an informed consent agreement regarding the processing of personal data. The data were stored electronically in digital form using the *Mi-*

crosoft Excel program, ensuring confidentiality and security of the information.

RESULTS

The study aimed to evaluate the effects of the CACS intervention on cognitive function, using two internationally recognized instruments: MMSE and MoCA. The results indicate a clear improvement in cognitive performance, illustrated both by the increase in the mean scores and by the statistical significance of the observed changes.

Specifically, the mean score on the MMSE test improved from 25.17, recorded before the intervention, to 26.33 after its application. This increase is supported by a t-statistic of -3.686 and a p-value of 0.000386, which means that the probability that the observed difference is due to chance is practically negligible. In addition, a correlation coefficient of 0.798 between the pre- and post-intervention scores confirms the existence of a strong linear relationship, indicating that the initial performance is a good predictor of subsequent cognitive improvement. Similarly, for the MoCA test, there was an increase in mean scores from 24.29 to 26.40. This difference is marked by a t-statistic of -10.737 and extremely small p-values (p one-tail = 3.72453x10^(-18) and p two-tail = 7.44906x10^(-18)), which emphasizes that the improvement is not attributable to chance. A correlation coefficient of 0.909 between pre- and post-intervention measurements highlights an almost perfect association, demonstrating the consistency and robustness of the cognitive improvements.

Statistically, an exceedingly small p-value indicates that the differences between measurements are significant and unlikely to arise from chance, which validates the effectiveness of the CACS intervention. Also, the remarkably high correlation coefficients (0.798 for MMSE and 0.909 for MoCA) reflect a close and predictive relationship between cognitive performance before and after the intervention, thus confirming the positive impact of applied method.

ANOVA analysis revealed that the specific diagnosis of the patients significantly influences cognitive performance, with an F of 142.86 (p ≈ 1.12x10^(-24)) for MMSE scores and 133.58 (p ≈ 1.59x10^(-23)) for MoCA scores. In addition, the correlation analyses between age and score variations (ΔMMSE and ΔMoCA) generated coefficients close to zero (approximately -0.00739 and -0.03891), indicating that age does not play a determining role in the evolution of cognitive performance post-intervention. Similarly, the weak relationship between the number of CACS sessions and changes in scores (r = 0.01645 for ΔMMSE and r = -0.03203 for ΔMoCA) suggests that the intensity of the intervention, measured by the number of sessions, is not a significant predictor of cognitive improvement.

For a visual understanding of the relationship between the studies variables, the following graphs were developed.

This graph shows the distribution of MMSE score variations according to age, highlighting a very low correlation coefficient (r ≈ -0.00739). Thus, it can be concluded that the age factor does not have a significant impact on cognitive improvement, suggesting that the benefits of CACS apply uniformly across the age range of patients.

Similarly, this graph indicates a correlation coefficient of approximately -0.03891, confirming that age differences are not associated with significant variations in MoCA scores. This finding supports the idea that the intervention produces positive results regardless of the age group.

Visual analysis of the data shows a weak correlation (r = 0.01645) between the number of sessions and MMSE score improvement. This observation suggests that although the number of sessions varies significantly between patients, the intensity of the interventions is not a direct predictor of cognitive improvement measured by MMSE.

Similarly, the analysis of the relationship between the number of sessions and the variation of MoCA scores indicates a non-significant correlation coefficient (r = -0.03202). This confirms that intensity (in terms of number of sessions) does not directly influence cognitive outcomes and other variables, such as the specificity of the diagnosis or individual characteristics of the patients, may play a more determining role.

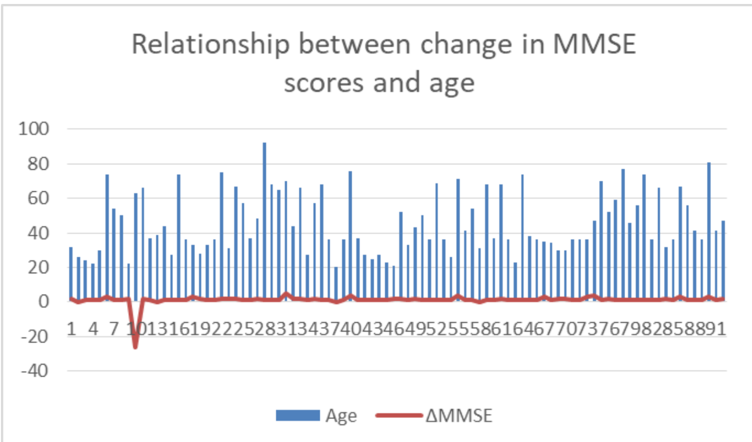

Fig. 1. Relationship between change in MMSE scores and age

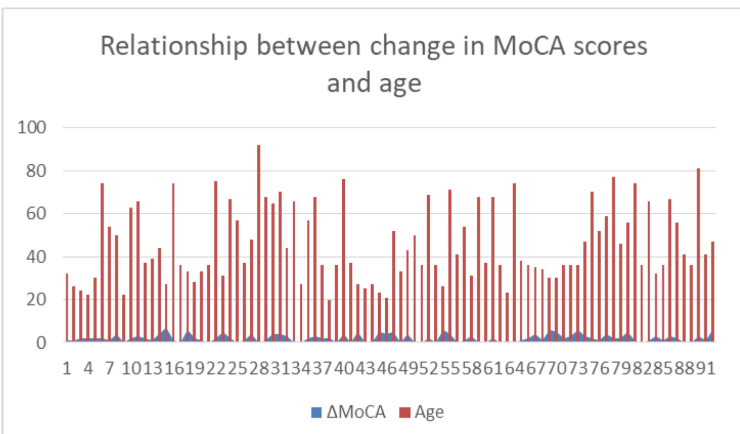

Fig. 2. Relationship between change in MoCA scores and age

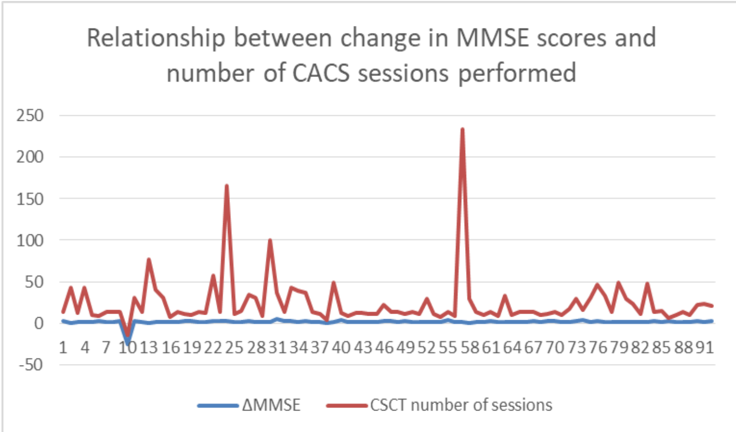

Fig. 3. Relationship between change in MMSE scores and number of CACS sessions performed.

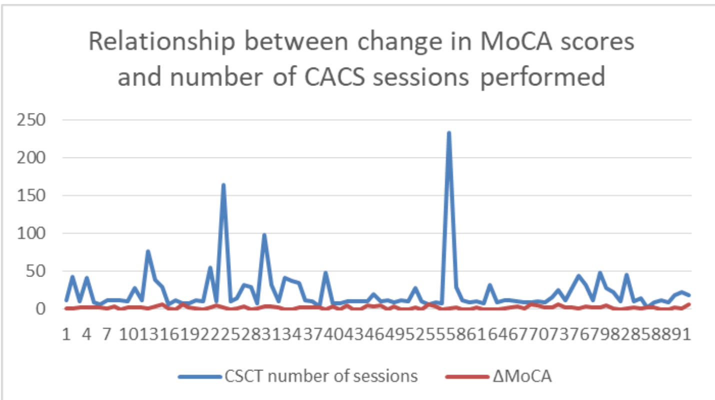

Fig. 4. Relationship between change in MoCA scores and number of CACS sessions performed.

Thus, the CACS intervention generated significant increases in cognitive function, and the statistical values obtained confirm both the real significance of these changes and the consistency of the improvements, demonstrating the effectiveness of the method within the study.

DISCUSSION

The study clearly highlights that CACS intervention leads to significant improvements in cognitive function, as reflected in the notable increase in MMSE and MoCA scores post-intervention. Paired-samples t-tests showed a significant mean difference: MMSE scores increased from 25.17 to 26.33 ($t = -3.686$; $p = 0.000386$; $r = 0.798$), and MoCA scores improved from 24.29 to 26.40 ($t = -10.737$; p one-tail $\approx 3.72 \times 10^{-18}$, p two-tail $\approx 7.45 \times 10^{-18}$; $r = 0.909$). ANOVA analysis also demonstrated that specific diagnosis has a significant impact on cognitive performance, with very high F-values ($F = 142.86$ for MMSE and F =

133.58 for MoCA, with $p < 0.001$ in both cases). These findings are in line with the literature, which supports that CACS can bring relevant benefits, but the response to treatment varies depending on the patient's diagnostic profile (3, 4).

The graphs completed the statistical analysis and provided additional visual interpretation. Figure 1 illustrates the relationship between age and ΔMMSE, and Figure 2. shows the relationship between age and ΔMoCA; both graphs highlight the correlation coefficients close to 0 ($r \approx -0.00739$ and $r \approx -0.03891$, respectively), confirming that age is not a significant predictor of improvement in cognitive function. Similarly, Figure 3 and Figure 4 show the relationship between the number of CACS sessions and the changes in scores (ΔMMSE and ΔMoCA) and the results show a very weak correlation ($r = 0.01654$ for ΔMMSE and $r = -0.03203$ for ΔMoCA). These observations suggest that, although it can be assumed that a higher intensity of the intervention could lead to superior outcomes, the number of sessions per se is not a significant predictor of cognitive improvements in this study.

Therefore, in the current context, the results demonstrate that the beneficial effects of CACS are determined by the specificity of the diagnosis rather than by demographic factors or the intensity of intervention, thus opening the way for future investigations to explore other moderating factors, such as the quality of the sessions or the initial stage of cognitive deficits. These aspects, highlighted both by statistical analysis and graphical representations, will be subject to detailed analysis in future discussions, thus providing a solid basis for optimizing non-pharmacological interventions in the management of cognitive deficits in patients with psychiatric disorders.

Despite the encouraging findings related to CACS, several limitations of the current study must be acknowledged. First, the inherent heterogeneity of psychiatric disorders and the variability in cognitive impairments among patients complicate the evaluation of CACS efficacy (9, 10. Many of the existing studies have been conducted with relatively small sample size and without rigorous control groups, which limits the generalizability of their findings (11, 12. Additionally, the reliance on self-reported measures of cognitive functioning may introduce bias, as patients' insight into their own cognitive deficits can vary considerably (13).

Furthermore, the current literature often does not adequately account for confounding variables such as medication effects, comorbid conditions and socio-demographic factors, all of which can significantly influence cognitive outcomes (14, 15). Future studies should strive to address these limitations by recruiting larger, more diverse samples and incorporating objective measures of cognitive functioning alongside self-report instruments (16, 17).

The promising efficacy of computer-assisted cognitive stimulation (CACS) in psychiatric disorders opens several exciting avenues for future research. As psychiatric treatment continues to advance, integrating CACS with conventional therapeutic modalities may further enhance cognitive outcomes in patients with diverse psychiatric conditions. Future investigations should prioritize longitudinal studies that examine the long-term effects of CACS on both cognitive functioning and psychiatric Symptoms, especially in populations with comorbid conditions (18, 19. In addition, employing advanced neuroimaging techniques to explore the neurobiological mechanisms underlying CACS may shed light on its influence on brain function and structure (20).

Moreover, the potential constructive interaction of combining CACS with non-invasive brain stimulation methods, such as transcranial magnetic stimulation (TMS) or deep brain stimulation (DBS), merits further exploration. Early evidence suggests that these combined approaches can amplify cognitive improvements and alleviate psychiatric symptoms (21, 22, 23).

This study has some limitations that need to be considered. First, the retrospective design may introduce biases related to the selection and quality of the available data. Second, the sample size and diversity of the study population may limit the generalizability of the results. Also, the lack of a control group reduces the ability to attribute direct causality to the intervention. In addition, variables such as treatment adherence and socio-economic factors were not controlled for, which could influence the results obtained.

CONCLUSIONS

The present study provides compelling evidence that CACS exerts a significant positive impact on cognitive function among patients with psychiatric disorders. Our statistical analyses revealed that both MMSE and MoCA scores improved markedly following the intervention, thereby confirming the clinical efficacy of CACS. Notably, the data indicates that the specific psychiatric diagnosis plays a pivotal role in determining cognitive outcomes, underscoring the importance of tailoring interventions to the individual's clinical profile. In contrast, neither age nor the number of cognitive stimulation sessions exhibited a significant correlation with the magnitude of cognitive improvements, suggesting that the therapeutic benefits of CACS remain consistent across different demographic groups and intervention intensities.

These findings advocate for the advancement of personalized CACS protocols, wherein interventions are adapted to the unique cognitive profile and diagnostic characteristics of patients. Future research should focus on refining these personalized approaches, as well as on exploring additional factors that might modulate treatment efficacy to ultimate optimize cognitive outcomes in psychiatric populations.

CONFLICTS OF INTEREST AND FUNDING

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