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Comparing the Effectiveness of Computer-Based and Task-Oriented Cognitive Rehabilitation Programs on Epileptic Children's Attention in Tehran

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Abstract

Background: There are important cognitive issues in patients with epilepsy, which can be referred to as impairment in executive functions such as attention.

Objectives: This research aims to compare the effectiveness of computer-based cognitive rehabilitation programs and task-oriented cognitive rehabilitation programs on attention in children with epilepsy in Tehran.

Methods: The present research was a semi-experimental study with a pre-test and post-test design with a control group. The statistical population of the study included all children with epilepsy who were referred to the neurology clinic of Mofid Children's Hospital in 2021. Using the purposeful sampling method, 45 eligible children were included in the study and were randomly divided into 2 experimental groups and 1 control group (15 people in each group). The Integrated Visual and Auditory Continuous Performance Test (IVA2) of Sohlberg and Mateer (2001) was used for data collection. The experimental groups underwent the intervention of the computerized cognitive rehabilitation program of the Cambridge Neuropsychological Test (1980) (12 sessions of 45 minutes) and the task-oriented cognitive rehabilitation program (12 sessions of 45 minutes). The control group did not receive any intervention. SPSS 20 software was used for data analysis. Univariate covariance analysis (ANCOVA) was performed using a significance level of 0.05.

Results: The results demonstrated that both computer-based cognitive rehabilitation programs and task-based cognitive rehabilitation were effective in increasing the attention of epileptic children in Tehran ($P < 0.001$). There was no significant difference between the effectiveness of computer-based cognitive rehabilitation programs and task-based cognitive rehabilitation in increasing the attention of epileptic children ($P = 0.67$).

Conclusions: It can be concluded that computer-based and task-oriented cognitive rehabilitation programs can be used to increase attention and executive functions in children with epilepsy.

Keywords: Attention, Computer-based Cognitive Rehabilitation Program, Epilepsy, Task-oriented Cognitive Rehabilitation Program

1. Background

As a feature of neurodevelopmental disorders (1), epilepsy manifests multilaterally with spontaneous and recurrent seizures and often injures the neural system. Furthermore, it is one of the most prevalent neurological diseases in the world. It is estimated that approximately 1 to 2% of the world's population has encountered this problem at some time in their lives (2). This disease is a set of medically chronic or long-term neural disorders characterized by epileptic attacks (3). Epilepsy is caused by the sudden charging of electrical signals by neurons in the brain (4). Genetic predispositions, developmental disorders, and nerve weaknesses are among the many reasons for epilepsy (5).

Significant cognitive problems reported in epileptic patients comprise disorders in executive functions such as attention. The process of selection, the intensity of attention (concentration), and the duration of attention to a certain stimulant (attention maintenance) constitute attention components that influence human awareness at every moment. In the meantime, sustained attention is defined as maintaining controlled processing when accomplishing a task. Hence, deficits in children's sustained attention fade the chances of processing, storing, and retrieving the information (6). Individuals with attention deficits do not process many pieces of information, lose the chance of storing and retrieving, and experience disorders in their memories (7). These processes affect other cognitive processes, especially learning. In this respect, Bandura emphasizes that every learning initiates with attention, and its inadequacy distorts individuals' learning (8).

Sustained attention is the capacity to maintain purposeful behavior during a continuous activity. It is activated when a salient stimulant exists in the perceptual field, and the right hemisphere of the brain, especially the right prefrontal cortex, is also activated (9). Research has demonstrated that people with myoclonic epilepsy have poor performance in focused attention, immediate and delayed recall, phonological memory, mental tracking, planning, and abstraction (10). In another study that was conducted on the executive functions of people with myoclonic epilepsy, they concluded that this group of patients has deficits in working memory, inhibitory control, concept formation, goal retention, mental flexibility, and verbal fluency. This attention deficit was detected in processes such as vigilance and concentration or when there was a need for sustained observation and divided attention (11).

Early seizures in childhood lead to disorders in brain development. In this regard, the cognitive problems of these individuals raise a significant debate that can form the foundations of the foremost neurological studies in the future. The therapeutic protocols of this group of patients constitute a set of therapeutic interventions, such as pharmacotherapy, family training, behavioral management, social and psychological support, and empowerment in executive functions. Cognitive rehabilitation is a therapeutic method for cognitive disorders and involves the return or compensation of impaired functions via training, repeating, and practicing strategies (12). At present, the interventions that improve executive functions are implemented with different methods, among which is the computer-based cognitive rehabilitation program. The self-directed computer-based cognitive rehabilitation programs allow infinite repetitions and gradual changes in practice difficulty and store reliable records of patients' functions in their information bank (13). The Cambridge Automated Neuropsychological Test Battery (CANTAB) is another computerized rehabilitation program designed for cognitive assessments. Research on the effectiveness of computer-based cognitive rehabilitation on sustained attention in children with autism spectrum disorder shows improvements in attention (14).

On the other hand, one of the effective treatments in this field is task-oriented cognitive rehabilitation. The findings of the research on the design of the beta circuit task cognitive rehabilitation package and its impact on the executive functions of dyslexic students have shown the positive and efficient effect of this type of rehabilitation on the executive functions of this group (15).

Studies have referred to the efficiency of the computer-based cognitive rehabilitation program in improving the working memory and cognitive flexibility of children with learning disorders (2), improving executive functions and working memory of adolescents between 15 and 18 with type I diabetes (16), improving the working memory, sustained attention, and mathematical performance of autistic children (14), and improving the sustained and complex attention of children with partial epilepsy and mild brain injuries (17).

In general, differences in the substance of the computer-based intervention can eliminate boredom stemming from the task type and accompany satisfaction to the epileptic child during the intervention.

2. Objectives

Each of these two programs has been examined by past studies addressing executive functions and their effectiveness on attention improvement. However, there is no study aiming to determine which one of these programs is more efficient. Hence, it is necessary to compare different therapeutic methods and determine the most effective and suitable intervention approaches. Accordingly, the present study aimed to compare the effectiveness of computer-based and task-oriented cognitive rehabilitation programs on the attention of children with epilepsy. For the purpose of the study, the researchers aimed to investigate whether there are any differences between the effectiveness of computer-based and task-oriented cognitive rehabilitation programs on the attention of epileptic children living in Tehran.

3. Methods

The present research was practical in terms of purpose and semi-experimental in terms of method with a pre-test, post-test, and follow-up design with a control group. The statistical population consisted of all 6-12-year-old epileptic children referred to the Neurology Clinic of Mofid Children's Hospital in Tehran in 2021. Out of this population, a sample of 45 children (15 per group) was selected by purposeful sampling with regard to the inclusion criteria of the study and randomly assigned into two experimental groups and one control group. The criteria for entering the research included children aged 6 to 12 years who were diagnosed with epilepsy by a pediatric neurologist. Children's willingness to participate in this research and parents' satisfaction with their children's presence and average intelligence (85 - 109) were the conditions for entering the research. They scored one standard deviation below the mean on tests of attention. They were not candidates for lobectomy surgery, and their seizures were controlled with medication. They were not infected with COVID-19 (PCR negative). Epilepsy was not resistant to treatment (refractory epilepsy), and they had no history of hospitalization in the pediatric neurology ward and the pediatric intensive care unit (PICU). They did not have autism, mental retardation, or other psychiatric disorders and could work with computers. Exclusion criteria included children's and their parents' dissatisfaction with the child's continued participation in the study, receiving a diagnosis of treatment-resistant epilepsy (refractory epilepsy) and hospitalization in the neurology ward and pediatric intensive care unit, contracting the coronavirus, not being able to work with a computer, and not participating in more than three training sessions. The data were analyzed by the ANCOVA test after being collected from the pre-test, post-test, and follow-up phases. Therapeutic interventions were carried out individually by the researcher, who had received specialized courses and workshops. Also, in order to comply with the ethical principles, after the completion of the intervention sessions on the experimental groups, a brief course of the cognitive rehabilitation program sessions was held for the control group.

3.1. Integrated Visual and Auditory Continuous Performance Test (IVA2/CPT)

IVA is a software test developed based on the attention model of Sohlberg and Mateer and assesses different types of attention (18). The test administration lasts 20 minutes (with training), and the task includes responding to or not responding to (response inhibition) the present stimulants. This test evaluates two main factors, i.e., response control and attention. The subject's task is to click once when they see or hear the number 1 and does not react if they see or hear the number 2. The presentation of the test is also such that the numbers 1 or 2 are either displayed in the form of a picture or are articulated in the form of voice and words. This software test, designed by the Brain Train Company, is a type of continuous performance test (CPT) whose results have been validated by those of fMRI (19) and QEEG (20). This test has been used for examining attention in patients suffering from brain strokes. The findings generally show that the test has proper validity and reliability in checking attention and diagnosing attention deficit and hyperactivity. Sandford and Turner reported that the test-retest reliability of the test was 75% (21). Another study found that the Neuropsychological Test Automated Battery had a test-retest reliability coefficient of 89% and a validation coefficient of 60%. This test has revealed proper sensitivity (92%) and positive predictive power (89%) to be used for measuring attention deficit and hyperactivity (22). To determine the reliability of the attention questionnaire, the present study employed the Cronbach alpha coefficient, which equaled 0.87 for the entire test.

3.2. Cambridge Neuropsychological Test Automated Battery (CANTAB)

This battery was presented by Cambridge University in 1980. Since that time, the university has been developing software for the test, which is counted as one of the most valid cognitive tests (23). This computerized battery has been built for simple, flexible, and easily-administered assessment and enables subjects to use touchscreens (24). Independent of cultures and languages, the test allows examining various domains of executive performance separately through five subscales. This study employed two subscales of the test, including spatial working memory and attention shift. This test has been used in many cases to evaluate cognitive items in patients with autism spectrum disorder, and its validity has been confirmed (25). In the "Spatial Active Memory" subtest, which is sensitive to the function of the frontal lobe and investigates executive disorders, A person's ability to retrieve spatial information and manipulate these items is evaluated (24). The extractable indices in the CANTAB test encompass the strategy and total error. Higher and lower scores in the strategy reflect poor and efficient use of the strategy, respectively. The total error includes the number of times a certain colored square is selected despite lacking the blue sign, found in the previous search, or researched in the same round in spite of lacking the target sign, which should not be selected by the subject (26). The attention shift test, which is sensitive to the forehead performance and examines executive dysfunctions, can measure a set of attentional shifts. A high internal consistency ranging from 0.73 to 0.95 has been reported for all subscales of CANTAB in 2-14-year-old children (24). In the present study, the Cronbach alpha coefficient of the attentional domain of the test equaled 0.88 for the reaction time of the 5-choice movements and 0.79 for the reaction time of the processing pace.

3.3. Beta Task-Oriented Cognitive Rehabilitation Program

Using paper and pencil, the beta task-oriented cognitive rehabilitation program emphasizes sustained attention. This program was adjusted by Ghasemi et al. (15) from easy to difficult according to its level of difficulty. Over the course of three months, children were presented with this package through 12 one-hour sessions (Table 1).

4. Results

The mean and standard deviation of the age group of the computer-based cognitive rehabilitation program is 2.37 ± 9.84, the mean and standard deviation of the age group of the task-oriented cognitive rehabilitation program is 2.90 ± 9.12, the mean and standard deviation of the age of the control group was 2.63 ± 10.32.

Table 2 shows the mean and SD of the research variables in the experimental and control groups in the pretest, posttest, and follow-up phases.

To ensure that these data could meet the ANCOVA assumptions, the researchers examined these assumptions before analyzing the hypotheses-related data. Thus, the data normality resultant from the significant Kolmogorov-Smirnov Z showed that the attention variable followed a normal distribution ($P = 0.066$; $Z = 0.201$). Furthermore, Levene's test was used for examining the assumption of the homogeneity of variances (for the equality of the variances in two experimental groups and one control group) ($F = 1.488$; $P = 0.234$). The results demonstrated that the homogeneity of variables assumption was established, and the covariance analysis was allowed. The ANOVA test was also employed to probe the assumption of the homogeneity of the regression slope ($F = 1.655$; $P = 0.204$). The insignificance of this interaction indicated the observance of this assumption. Hence, the assumption of the homogeneity of the regression slope was also established for the research variables, and this test could be applied. Table 3 represents the ANCOVA results.

As Table 3 displays, the F-value of the univariate ANCOVA for the dependent variable indicates that the computer-based cognitive rehabilitation, task-oriented cognitive rehabilitation, and control groups were significantly different in their attention. Thus, minimally, one of the interventions significantly impacted the dependent variable. To find out which intervention was effective and if there were significant differences between interventions, the researchers used the Bonferroni test, whose results are provided in Table 4.

As observed in Table 4, the mean difference between the computer-based cognitive rehabilitation group and the control group was 12.787, which was significant at the 0.01 level. This finding shows that the computer-based cognitive rehabilitation program increased attention. Similarly, the mean attentional difference between the task-oriented cognitive rehabilitation group and the control group equaled 12.905, which was also significant at the 0.01 level. This outcome shows that the task-based cognitive rehabilitation program influenced attention as well. Besides, the difference between the computer-based cognitive rehabilitation group and the task-oriented cognitive rehabilitation group in the attention variable equaled 0.118, which was not significant at the 0.05 level. This result indicates that these two groups were not significantly different in their attention. The ANCOVA results of the follow-up phase are presented in Table 5.

As Table 5 demonstrates, the F-value of the univariate ANCOVA for the dependent variable shows that there were significant attentional differences among the computer-based cognitive rehabilitation, task-oriented cognitive rehabilitation, and control groups. Therefore, at least one of the interventions significantly impacted the dependent variable. To determine which intervention was effective and if there were significant differences between them, the Bonferroni test was used, and the results are presented in Table 6.

As observed in Table 6, the mean difference between the computer-based cognitive rehabilitation group and the control group equaled 12.253, which was significant at the 0.01 level. This finding shows that the computer-based cognitive rehabilitation program improved attention up to the follow-up phase. Furthermore, the mean attentional difference between the task-oriented cognitive rehabilitation group and the control group equaled 11.393, which was significant at the 0.01 level. This demonstrates that the task-oriented cognitive rehabilitation program continued its impact till the follow-up phase. In addition, the mean attentional difference between the computer-based and task-oriented cognitive rehabilitation groups equaled 0.860, which was not significant at the 0.05 level. Thus, these two groups were not significantly different in their attention in the follow-up phase.

5. Discussion

The present study was conducted to compare the effectiveness of computer-based and task-based cognitive rehabilitation programs on the attention of children with epilepsy. The results showed that both computer-based and task-oriented cognitive rehabilitation programs improved the attention of epileptic children living in Tehran, and this improvement continued until the

Table 1. Content of Task-oriented Cognitive Rehabilitation Sessions (15)

Session	Objective	Content
1	Introducing each other and informing the parents about the necessity of rehabilitation	A general session for all families whose children participated in the study. Explaining the significance of cognitive rehabilitation training by foregrounding executive functions and their roles in everyday life, academic achievement, and social skills, pretest
2	Improving visual working memory, Sustained visual attention and inhibition	(1) Working memory: Practice memorizing flashcards in order (Working Memory Enhancement Pack); (2) Inhibition: Yes and no reverse answer and pantomime sitting and walking; (3) Continuous attention: Continuous attention exercises based on IVA2 (search for visual cues) and teaching exercises and giving weekly assignments
3	Improving visual working memory sustained visual attention and inhibition	Review of previous exercises and feedback from exercises performed; (1) Working memory: Practice memorizing patterns (patterns of geometric shapes and sticks) according to the instructions; (2) Inhibition: Practice matching numbers (writing and math)
4	Improving visual working memory and auditory, continuous auditory attention, and Inhibition	Review of previous exercises and feedback of exercises and (1) Working memory: Practice memorizing numbers with the cube (visual and auditory) according to the instructions (working memory improvement package); (2) Inhibition: Word inhibition exercises; (3) Continuous attention: Continuous attention exercises based on IVA2 (listening with emphasis on the target word) and teaching exercises and giving weekly assignments
5	Improving visual working memory sustained auditory attention and inhibition	Review of previous exercises and feedback from the exercises: (1) Working memory: Practice memorizing the order of the colored cars of the tunnel according to command (working memory optimization package); (2) Inhibition: Practicing traffic lights and signs; (3) Continuous attention: Continuous attention exercises based on IVA2 (listening attention) and teaching exercises and giving weekly homework
6		Reviewing all past exercises (5 sessions) and getting feedback
7	Improving visual working memory and auditory, continuous visual attention and hearing, inhibition	Review of previous exercises and feedback from the exercises: (1) Working memory: Practicing memorizing cubes and colored glasses and practicing words; according to the command (working memory optimization package); (2) Inhibition: Digit inhibition exercises (digit inhibition and expressing their number); (3) Continuous attention: Continuous attention exercises based on IVA2 (auditory and visual). Teaching exercises and giving weekly assignments
8	Improving visual active memory, continuous visual and auditory attention, Inhibition	Review of previous exercises and feedback from the exercises: (1) Working memory: Practice memorizing the cubes of letters and words according to the order (Arjamandania, Ghasemi, 2017); (2) Inhibition: Practicing guide signs and counting numbers forward and backward; (3) Continuous attention: Continuous attention exercises based on IVA2 (auditory and visual). Teaching exercises and giving weekly assignments
9	Improving visual working memory and auditory attention continuously visual and Hearing, inhibition	Review of previous exercises and feedback from the exercises: (1) Working memory: Practicing memorizing color cards and pictures according to the instructions (Arjamandania and Ghasemi, 2017); (2) Inhibition: practice playing with colored balls (dominant color, dominant leg) and researcher-made software practice; Inhibition Derived from flanker test; (3) Continuous attention: Continuous attention exercises based on IVA2 (auditory and visual). Teaching exercises and giving weekly assignments
10	Improving auditory working memory sustained visual attention and inhibition	Review of previous exercises and feedback from the exercises: (1) Working memory: Practice memorizing verbs according to the order, practice memorizing words and deletion; required letters and remembering the new word (auditory) (Khodadi and Ghasemi, 2017); (2) Inhibition: Matching pictures and heterogeneous names exercise, software exercise of Stroop test; (3) Continuous attention: Continuous attention exercises based on IVA2 (auditory and visual) and teaching and giving weekly homework
11	Improving visual working memory, Sustained visual attention and inhibition	Review of previous exercises and feedback from the exercises: (1) Working memory: Practicing Peru's room, remembering the color of the clothes and the name of the person (Arjamandania and Ghasemi, 2017); (2) Inhibition: Software exercise of inhibition from the Stroop test; (3) Continuous attention: Continuous attention exercises based on IVA2 (auditory and visual) and teaching and giving weekly homework.
12	Improving visual working memory and auditory, continuous visual attention and hearing, inhibition	Review of previous exercises and feedback from the exercises: (1) Working memory: Reviewing the exercises of the improvement package and the book on improving working memory; (2) Inhibition: Reviewing the exercises of the past sessions; (3) Continuous attention: Continuous attention exercises based on IVA2 (auditory and visual), and teaching exercises and giving weekly assignments
13	Posttest	

Table 2. Mean and SD of Dependent Variable in Experimental and Control Groups in Pretest, Posttest, and Follow-up Phases

Dependent Variable and Measurement	Pretest	Posttest	Follow-up
Attention			
Computer-based cognitive rehabilitation program	68.45 ± 9.76	85.60 ± 9.73	84.85 ± 12.77
A task-oriented cognitive rehabilitation program	69.85 ± 15.43	86.65 ± 13.07	84.95 ± 12.14
Control group	64.30 ± 8.71	70.05 ± 15.96	69.75 ± 13.50

Table 3. Univariate ANOCOVA Results of Post-test Attention Scores

Dependent Variable	Sum of Squares	df	Mean Squares	F	P-Value	Eta Square	Effect Size
Attention	2115.059	2	1057.530	9.190	0.001	0.247	0.970

Table 4. Post-hoc Bonferroni Test Results for Comparing Differences in Attention Means of the Computer-based Cognitive Rehabilitation, Task-oriented Cognitive Rehabilitation, and Control Groups in the Post-test

Variable and Compared Groups	Mean ± SD	P-Value
Attention		
Computer-based cognitive rehabilitation - control group	12.787 ± 3.430	0.0001
Task-oriented cognitive rehabilitation – control group	12.905 ± 3.459	0.0001
Computer-based cognitive rehabilitation – task-oriented cognitive rehabilitation	0.118 ± 3.397	0.682

Table 5. Univariate ANCOVA Results of Follow-up Attention Scores

Dependent Variable	Sum of Squares	df	Mean Squares	F	P-Value	Eta Square	Effect Size
Attention	1801.384	2	900.692	8.842	0.0001	0.240	0.964

Table 6. Post-hoc Bonferroni Test Results for Comparing Differences in Attention Means of the Computer-based Cognitive Rehabilitation, Task-oriented Cognitive Rehabilitation, and Control Groups in the Follow-up Phase

Variable and Compared Groups	Mean ± SD	P-Value
Attention		
Computer-based cognitive rehabilitation - control group	12.253 ± 3.227	0.0001
Task-oriented cognitive rehabilitation – control group	11.393 ± 3.254	0.0001
Computer-based cognitive rehabilitation – task-oriented cognitive rehabilitation	0.860 ± 3.196	0.412

follow-up phase. Moreover, according to the findings, the computer-based and task-oriented groups were not significantly different in their attention in the post-test and follow-up phases. Overall, the findings indicate that both interventions effectively improved attention in children with epilepsy. This outcome is in line with the results of studies by Javanmard (16), Nazarboland et al. (14), and Kaldoja et al. (17). This can be explained by the argument that selective attention is the most prevalent and conventional use of the general term of attention, which refers to the capacity to selectively processing relevant pieces of information and ignoring irrelevant ones. A thread that selectively processes some events and ignores others. It seems that conscious concentration is the integral component of this level of attention. In other words, the brain can only attend to a limited number of topics at every moment in order to focus on task-related stimulants (14).

A significant amount of information we receive requires prior selection; otherwise, we become overwhelmed and unable to process it effectively. This issue necessitates the selection of information. We can deduce that the performance improvement after the cognitive rehabilitation interventions reflects changes in the neural system that can be explained according to the hypothesis posing brain plasticity resultant from neuropsychological practices (16).

It is assumed that the same mechanism that forms the foundations of the experience-dependent plasticity processes leads to directed improvement through cognitive rehabilitation. Confusion at this level of attention arises when one can attend to a topic only for a short time and fails to perform attention-needing tasks. This research demonstrated a significant increase in the attention scores of the experimental groups in the post-test and follow-up phases. To explain this, we can rely on the principles of neural plasticity and improvement and claim that cognitive rehabilitation exercises, molded into multistage programs and hierarchies, can strengthen the attention of epileptic children. In addition, cognitive components involving attention, memory, and executive functions overlap, coordinate, and cooperate using complex methods. For this reason, it is hard to discuss a process irrespective of these components, while the promotion of one may positively impact the performance of other domains and components (27).

On the other hand, post-trauma exercises, i.e., re-learning mental actions and processes, are vital stimuli for building new and effective operational relationships in the remaining tissue. Practicing skills can influence brain flexibility. There is evidence that recovery after cognitive rehabilitation is due to the flexibility of training in neural networks. Since the brain is highly capable of reorganizing cognitive neurons, structured stimulation improves the behavioral function of neurons (17). This issue can explain the effectiveness of computer-based and task-oriented cognitive rehabilitation on the components of executive functions, i.e., inhibition, transfer, emotional control, planning, component organization, monitoring, working memory, and initiation.

5.1. Conclusions

Generally, the results of this research emphasize the importance of using computer-based and task-oriented cognitive rehabilitation in improving the attention and executive functions of children with epilepsy. It should be emphasized that one of the most important educational and rehabilitation goals of children with epilepsy is improving their cognitive skills. In the meantime, children can highly benefit from computer-based and task-oriented cognitive rehabilitation that promotes their executive functions as the most important cognitive skills. For this reason, informing parents, teachers, coaches, and therapists, and introducing practical approaches to school authorities, and making experts in education and well-being organizations aware of the significance of computer-based and task-oriented cognitive rehabilitation can extensively improve the executive functions of children with epilepsy. It is suggested to combine research variables with the moderating role of gender in future research to compare male and female students with epilepsy. Since the statistical population of the research is limited to the city of Tehran, caution should be used to generalize the results to other cities.

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Footnotes

Authors' Contribution: The study concept and design were developed by F. N. and A. K. Data analysis and interpretation were carried out by R.J. and M.J. A. K drafted the manuscript. M. J., R.J., and F.N. critically revised the manuscript for important intellectual content. Statistical analysis was conducted by F. N. All authors read and approved the final manuscript.

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Data Reproducibility: Datasets are available upon request during submission or after publication. Due to privacy and ethical concerns, the data is not available to the public.

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