



ORIGINAL ARTICLE

The Effects of Cognitive Enhancement Drug (Coluracetam) on Visual Perception, Abstract Reasoning, Pattern Recognition, Spatial Orientation, and Analytical Thinking: A Case Study

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Abstract

New medications to treat cognitive disorders may improve cognition in healthy individuals. However, limited studies were conducted on its efficacy among individuals without cognitive deficiencies. Thus, this case study aimed to explore the effects of using a cognitive enhancement drug (Coluracetam) on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking in a healthy adult male for three months. This case study utilized a mixed-method case study design. Data on the case presentation, investigation, treatment, physical and mental effects experienced by the respondent with Coluracetam were gathered from the respondent through a face-to-face interview. To measure the respondent's visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking, our case study used the Brain Metrics Initiative (BMI)TM IQ test. Moreover, the researchers collated the pretest and posttest data on the respondent's visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking during the first week of the first month and in the third month of using Coluracetam. Data were statistically analyzed using IBM SPSS version 27. There was an increase in visual perception, abstract reasoning, pattern recognition, and analytical thinking scores in the posttest; however, there was a decrease in spatial orientation scores in the posttest result. The test of significant difference between the increase and decrease in the pre-post test scores on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking indicates a statistically

insignificant result ($t = -0.33$, $p = 0.75$). On the contrary, our findings showed a significant relationship between the pretest and posttest scores on the five variables since the computed values indicate ($R^2 = 0.95$, $F = 61.98$, $p = 0.004$). Our study provides evidence that there is no significant difference between the pre-post test results on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking but has a significant relationship between the five variables aforementioned after using the cognitive enhancement drug (Coluracetam) for three months.

Keywords

Cognitive enhancement drugs, Coluracetam, Visual perception, Abstract reasoning, Pattern recognition, Spatial orientation, Analytical thinking

Introduction

Cognitive enhancement is described as "the augmentation or expansion of the mind's basic capacity through the improvement of its internal and external information processing systems" [1]. Cognitive enhancers (CEs), sometimes known as "smart medicines" or "nootropics," are a heterogeneous collection of pharmacological agents intended to enhance cognitive function, specifically memory, alertness, attention, learning performance, creativity, and motivation [2].

CEs are frequently acquired, and occasionally by healthy individuals [1,3], via prescription, over-the-counter, online, or other sources such as family or friends. The therapeutic impact of ingesting CEs can be substantial, as these molecules can affect numerous neurotransmitter pathways in the brain, such as the cholinergic, dopaminergic, noradrenergic, and serotonergic pathways [4].

Moreover, CEs are mainly multidimensional and intricate, with distinct compounds acting in different ways and on different (and frequently many) receptors in the Central nervous system (CNS) [5]. "Natural" enhancers such as nicotine and caffeine [6-8] are commonly recognized as chemicals that improve our concentration, wakefulness, and productivity. Food-based antioxidants, herbs, and other food-derived nootropic substances have grown increasingly popular in recent years as there have been suggestions of correlations between cognition and diet [9].

Coluracetam (code name BCI-540; formerly MKC-231) belongs to the class of cognitive enhancement of the racetam family, which is believed to improve mental performance in cases of cognitive disorders [10]. It was initially developed and tested by the Mitsubishi Tanabe Pharma Corporation for Alzheimer's disease. Depending on the disease process being modeled, putative mechanisms of action include increased membrane fluidity, increased neurotransmitter release (e.g., dopamine), protective effects on specific receptors (e.g., glutamate and choline), increased blood flow, improved corticosteroid function, and effects on calcium channel function [11-14]. However, research on the usefulness of Coluracetam to improve cognitive impairments in these individuals and animal trials have typically yielded inconclusive or minor results [15-18].

Furthermore, Coluracetam studies [19-23] have been shown to reverse the loss of choline acetyltransferase production in the medial septal nucleus of rats exposed to phencyclidine (PCP) and is considered a potential therapeutic drug for schizophrenia. Coluracetam also enhances high-affinity choline uptake (HACU), which is the rate-limiting step of acetylcholine (ACh) synthesis [13,16,20].

The oral dose of 300 - 3,000 mcg/kg bodyweight used in animal studies on Coluracetam generally corresponds to a human dose of 48 - 480 mcg/kg or (for a 150 - pound individual) 3.2-32.7 mg overall [16] and it appears to have extremely quick kinetics, with a peak concentration in the blood at roughly 30 minutes and a subsequent fall within three hours. Consequently, supplementation may be time-sensitive concerning physical activity [20]. Due to limited human studies conducted on the use of Coluracetam, most literature [13,16,21] were based on first-hand experiences of those who used Coluracetam. Most of the respondents reported feeling more alert, happier, and less worried, and some claimed to have a

superior memory but were unable to explain why [16]. In contrast, some individuals also experienced increased anxiety, mental fog, and inability to concentrate [13]. These adverse effects are typical among individuals with excessive choline levels [16,20].

In this connection, it is essential to note that most literature on Coluracetam as a Cognitive Enhancement are limited and primarily includes *in vitro* and *in vivo* studies [10,18,19,21,24] and first-hand experiences published as blogs [13,16,20,25]. To the best of our knowledge, we are the first to report on the effects of Coluracetam as a Cognitive Enhancement on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking in a healthy adult male for three months. Thus, this study is conducted. The main objective of this case study is to find out if there are significant differences and relationships between the pretest and posttest visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking using the Brain Metrics Initiative (BMI)[™] IQ test after three months of taking Coluracetam 20 mg/day dose.

Methods

Study design

The present study utilized a mixed-method case study design. Data on the case presentation, investigation, treatment, physical and mental effects experienced by the respondent using Coluracetam were gathered from the respondent through a face-to-face interview. Moreover, data on the respondent's visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking were collected during the first week of the first month and the third month of using Coluracetam using the Brain Metrics Initiative (BMI)[™] IQ test. All data were statistically analyzed using IBM SPSS version 27.

Case presentation

A 36-year-old Asian male respondent with no history of physical and mental disorders and comorbidities. Moreover, he has a doctorate degree and is an active researcher with publications in Scopus, Web of Science, and ISI-indexed journals.

Investigation and treatment

The respondent decided to incorporate cognitive enhancement since he noticed that only anecdotes and first-hand subjective experiences on Coluracetam and its effectiveness in improving visual functioning, thinking, memory, and attention were published. Furthermore, limited peer-reviewed research studies were conducted on Coluracetam's efficacy on cognitive improvement.

The calculation of the dose of Coluracetam was based on the available literature and articles by Tomen [25], Patel [16] and [20] with a minimum recommended

dose protocol of 20-40 mg/day in two divided doses. In this case study, the respondent took the minimum dose of 20 mg/one capsule daily with breakfast for three months. Moreover, he accompanied this dose with regular 30-45 minutes of physical activity daily, i.e., brisk walking, a balanced and nutritious diet seven times per week, and a regular sleep pattern between 7-10 hours of sleep per night, which he believed will contribute in maximizing his cognitive functioning.

Instrument and monitoring

To measure visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking, the researchers, in collaboration with the respondent, chose the Brain Metrics Initiative (BMI)[™] IQ test because it captures the aforementioned variables being evaluated in this case study.

Brain Metrics Initiative (BMI)[™] is a technology-enabled organization committed to creating high-quality online psychometric testing tools to provide individuals and small businesses with access to one of the most comprehensive, secure, and cost-effective assessment options [26]. Moreover, the Brain Metrics Initiative (BMI)[™] includes developing not only IQ tests but also Personality Test, Career Personality & Aptitude Test, and AI -Powered Recruitment Assessments.

Most tests involving visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking employ the IQ test [27]. IQ, often known as the Intelligence Quotient, is the most explored method for measuring human intelligence and has the most practical uses to date [9,28]. In addition, research further proved a correlation exists between IQ and academic achievement (Christy & Huffine, 2021), employment performance [29], and money [28]. Furthermore, these studies [1,2,5,23] established that IQ is a predictor of educational, occupational, economic, and social success.

The researchers collated the pretest and posttest data on the respondent's visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking during the first week of the first month and in the third month of using Coluracetam.

Statistical treatment

Data on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking were expressed as means with standard deviations. To test if significant difference exists between the pre-post tests on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking, a paired two-tailed t-test was utilized. Moreover, linear regression analysis was used to test if significant relationship exists between the pre-post tests on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking.

Scoring procedures

For this case study, we employed the scoring range on the visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking provided by the Brain Metrics Initiative (BMI)[™] IQ test [26] (Table 1).

Outcome and Follow-up

First, second, and third month subjective reports on the physical and mental effects of cognitive enhancement drug (Coluracetam)

First-month subjective reports on the physical and mental effects of cognitive enhancement drug (Coluracetam): During the first month of a face-to-face interview with the respondent, he verbalized that:

"I did not experience any mental improvements during the first month of using Coluracetam. However, I experienced a slight headache that lasted around 2-3 minutes during the first two weeks of using Coluracetam. I actively do my 30-45 minutes of physical activity and diet regimen and try to get 7-8 hours of sleep per night."

Second-month subjective reports on the physical and mental effects of cognitive enhancement drug (Coluracetam): In the second month, the respondent stated that:

"This time, I noticed that everything I see is in high definition (HD). Moreover, when I had writer's block, it usually took me a day or two before I resumed writing. But now, I can finish a specific writing task within the day. I also noticed that the headaches I experienced during the first month diminished. Moreover, I don't think that

Table 1: Scoring procedure.

Score Range	Verbal Description	Interpretation
90-100	Excellent	Respondent's visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking scores are at a superb level.
80-89	Above Average	Respondent's visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking scores are above-average level.
70-79	Average	Respondent's visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking scores are at a moderate level.
Below 69	Poor	Respondent's visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking scores are at a below-average level.

Table 2: Test of significant difference between the pre-post tests on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking.

Variables	Pretest Scores	Description	Posttest Scores	Description	Mean	SD	t-value	p-value
Visual Perception	90	EX	100	EX	64.60	± 25.02	-0.33	0.75
Abstract Reasoning	60	BA	63	BA				
Pattern Recognition	30	P	38	P				
Spatial Orientation	55	P	50	P				
Analytical Thinking	88	AA	100	EX				

Legend: SD: Standard Deviation; **Description:** Excellent (EX) = 90-100, Above Average (AA) = 80-89, Average (A) = 70-79, Below Average (BA) = 60-69, Poor = Below 69; Significance Level $\alpha = 0.05$; two-tailed paired t-test.

the cognitive improvements I experienced were merely because of Coluracetam. I believe it is a combination of regular physical activity, proper nutrition, and regular sleep."

Third-month subjective reports on the physical and mental effects of cognitive enhancement drug (Coluracetam): During the third-month follow-up, the respondent verbalized that:

"At this time, aside from the visual improvements I experienced with Coluracetam, I also observed improvements in my writing capabilities, mainly when writing the discussion portion of my research. For me, while on Coluracetam, it improved my subjective evaluation of my abstract reasoning, pattern recognition and analytical thinking, especially in presenting conflicting findings in the literature. I find it easy to connect ideas in my writing. In short, it made my intelligence fluid."

Test of significant difference between the pre-post tests on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking

The test of significant difference between the pretest-posttest scores on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking of the respondent with the corresponding mean, standard deviation, t, and p values are presented in [Table 2](#) and were statistically treated using a two-tailed paired t-test. The visual perception in the pretest indicated a score of 90 and increased to 100 in the posttest. Regarding abstract reasoning, the pretest score is 60 and increased to 63 in the posttest. Furthermore, pattern recognition scored 30 on the pretest and increased to 38 on the posttest. While analytical thinking got a pretest score of 88 and increased to 100 in the posttest. However, spatial orientation got a pretest score of 55 and decreased to 50 in the posttest. The overall computed mean for the five variables is 64.60, with a standard deviation of ± 25.02 . The test of significant difference between the increase and decrease in the pre-post test scores on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking indicates statistically insignificant results since the t and p values indicate ($t = -0.33$, $p = 0.75$).

Table 3: Test of significant relationship between the pre-post tests on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking.

Variables	R Square (R ²)	F	p - value
Visual Perception	0.95	61.98	0.004
Abstract Reasoning			
Pattern Recognition			
Spatial Orientation			
Analytical Thinking			

Significance Level $\alpha = 0.05$; Linear Regression Analysis

Test of significant relationship between the pre-post tests on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking

[Table 3](#) presents the results of the test of significant relationship between the pre-post test scores on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking using Linear Regression Analysis. As can be gleaned in [Table 3](#), the results indicate a significant relationship between the pretest and posttest scores on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking since the computed values showed ($R^2 = 0.95$, $F = 61.98$, $p = 0.004$).

Discussion

This case study's objective was to determine if there were significant differences and significant relationships between the pre-post test scores on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking after using the cognitive enhancement drug (Coluracetam) for three months. Our results indicate an increase in visual perception, abstract reasoning, pattern recognition, and analytical thinking scores in the posttest; however, there was a decrease in spatial orientation scores in the posttest. Moreover, the test of significant difference between the increase and decrease in the pre-post test scores on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking indicates a statistically insignificant result ($t = -0.33$, $p = 0.75$). On the contrary, our findings showed a significant relationship between the pretest and posttest scores on

the five variables since the computed values indicate ($R^2 = 0.95$, $F = 61.98$, $p = 0.004$).

Visual perception

Visual perception is the visual-cognitive attribute that helps the individual arrange, process, and interpret visual information to gain understanding and meaning from what the individual sees [30]. Furthermore, it is the ability that demonstrates how sharp the individual's capacity to identify even the slightest changes in forms and shapes of items is and how effectively he can determine similarities or distinctions based on size, color, or measurements. Our findings aligned with the studies of Akaike, Bessho, and Takashina [10,15,19,31] on the association between Coluracetam in improving visual perception. Coluracetam predominantly influences the high affinity choline uptake (HACU) pathway (Peak Nootropics, 2014) and is recognized to be a powerful cholinergic cognitive enhancer [32]. These cholinergic effects play a vital role in cognitive processes such as vision, memory, learning, and arousal [20].

Abstract reasoning

Abstract reasoning is the ability to comprehend new ideas and abstract notions without relying on previously acquired knowledge [33,34]. In addition, it is a set of questions that assesses general intellectual potential without enabling variables such as educational level, social background, or life experience to influence the results. Based on the subjective experience of the respondent, he observed that he found it easy to connect his ideas in writing and improved his fluid intelligence. His experience with Coluracetam in improving abstract reasoning agrees with Patel and Tomen [16,25] that Coluracetam promotes a more relaxed, tranquil, and open-minded mode of thought. Furthermore, some claim that Coluracetam improves meditation and the feeling of being at peace with the world [13].

Pattern recognition

Pattern recognition is recognizing, identifying, and classifying complex arrangements of sensory stimuli to aid memory storage and retrieval [30]. Moreover, it is a spontaneous and automatic process that determines a person's ability to discern order in chaotic circumstances. Pattern recognition correlates strongly with general intelligence since it determines your ability to think logically and recognize and interpret logical sequences [33,35]. In this connection, the respondent stated that in his third month of using Coluracetam, improvement in his ability to identify patterns between conflicting findings in articles or literature he reads was observed. According to Shirayama and Takashina studies [10,22] the high affinity choline uptake (HACU) of Coluracetam which is the uptake of choline at the synapse for acetylcholine production and is considered a rate-limiting step in acetylcholine synthesis resulted

into the activation of cholinergic neurons which aids in improving pattern recognition attributes.

Spatial orientation

Spatial orientation is the cognitive ability that enables the individual to comprehend spatial relationships, i.e., the capacity to recognize and visualize the orientation of things in space and make sense of their various interactions in a given environment [36]. Since time immemorial, the collection of spatial orientation questions has been created to measure the precision with which you perceive the locations and movements of objects in space. In our case study, the respondent's posttest score on spatial orientation decreased by 5 points. However, in literature [15,19,37] it was found that Coluracetam improves spatial orientation by inducing long-lasting pro-cognitive effects by modifying the choline transporter regulation system.

Analytical thinking

Analytical thinking is the capacity to break down available knowledge into smaller pieces and then evaluate and synthesize those smaller pieces to formulate logical solutions to issues or make rational decisions based on facts [38]. In addition, analytical thinking is believed to have the highest link with problem identification and problem-solving ability. It also influences how quickly and effectively an individual can recognize problems and work out suitable solutions. Our findings agree with the studies by Cohen, Napotelano, and Patel [5,21,24] that Coluracetam improved analytical thinking by reversing acetylcholine deficit resulting in improvement in vision, memory, awareness, and thinking process.

Aside from the correlation of using Coluracetam on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking, some research [5,21,24] established that the mechanism of action of Coluracetam might prevent specific mood-altering adverse effects of other cholinergics, such as Piracetam. According to the aforementioned studies, some individuals who take Piracetam and related racetams may exhibit depressive symptoms, unlike Coluracetam which has been reported to have some modest antidepressant properties; however, there were no robust evidence to prove this claim.

Furthermore, studies on Coluracetam were limited, and most of the pieces of literature were based on studies conducted *in vitro* and *in vivo* [10,15,19] and first-hand experiences that were published as blogs [13,16,25], reviews [10,18,19,21,24] and. In fact, since 2014, the company Brain Cells In which conducted research on Coluracetam explicitly on its role as a potential medication for Alzheimer's and its possible applications as management for other cognitive disorders as well as mental/psychiatric disorders, specifically on depression, anxiety, and schizophrenia has been discontinued and

there is no ongoing research on Coluracetam has ever progressed [20].

The respondent in the case study verbalized that although Coluracetam has improved his visual perception and fluid intelligence subjectively, he will not continue using it because, for him, a healthy lifestyle, i.e., regular physical activity, eating nutritious foods, and quality sleep, have contributed more to his cognitive capabilities compared with using Coluracetam. Lastly, our case study has some limitations. First, the outcome variables were assessed using self-reporting techniques and reported only mean differences and relationships in the respondent's pre-post test scores on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking, which may not capture the entirety of a comprehensive assessment of mental cognition capabilities. Second, we only use one test (Brain Metrics Initiative (BMI)[™] IQ test to evaluate the respondent's cognitive functions, which brings a generalized conclusion based only on the five aforementioned variables. Moreover, our results of this case study only referred to a respondent without physical or mental impairments and comorbidities.

Conclusion

Our study provides evidence that there is no significant difference between the pre-post test results on visual perception, abstract reasoning, pattern recognition, spatial orientation, and analytical thinking but has a significant relationship between the five variables aforementioned after using the cognitive enhancement drug (Coluracetam) for three months.

Statement of Authorship

All authors certified in fulfillment of ICMJE authorship criteria.

Author Disclosure

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