Title: Investigating the Effects of Combined Caffeine Treatment and Video Games on the Treatment of Amblyopia in Adults

Abstract: Amblyopia is a visual disorder that typically begins in childhood, and if left untreated, the chances of improvement in adulthood decrease significantly. This condition is associated with reduced visual processing ability and contrast sensitivity in one or, in some cases, both eyes, and the existing treatments for adults have limited effectiveness. The aim of this study is to investigate the effects of combined caffeine treatment and standardized video games on improving visual performance in adults with amblyopia. The subject of this study is a 46-year-old woman who developed amblyopia due to childhood strabismus, with previous treatments proving ineffective. Preliminary results indicate that the combined treatment using caffeine and video games leads to a 30% improvement in visual processing and vision strength.

Introduction: Amblyopia, which affects approximately 3% of the global population, is a visual disorder caused by the inability of the eye to develop normal vision during childhood. This condition often arises due to refractive errors, strabismus, or physical obstructions in the visual pathway. Consequently, the brain favors the healthy eye for vision and deactivates the pathway transmitting images from the affected eye, leading to reduced visual performance and lazy eye. If untreated during childhood, the chances of improvement in adulthood decrease significantly due to factors such as reduced neural plasticity and the stabilization of inhibitory processes.

Existing treatment methods, such as patching the dominant eye or visual exercises, though more effective in children, have limited efficacy in adults due to neural constraints and practical challenges. In certain cases, such as the patient in this study, traditional treatments fail due to interference with daily vision or lack of patient compliance.

This study investigates the combined effects of caffeine, as a cognitive stimulant, and video games, as a tool for visual stimulation, on improving visual performance in adults with amblyopia. The aim of this research is to propose an innovative solution to overcome the limitations of previous treatments and enhance the effectiveness of amblyopia therapy in adults.

Case Description:

Medical History: The patient is a 46-year-old woman who has had monocular amblyopia in her right eye since childhood due to strabismus. At the age of six, she underwent interventions including surgery to correct the misalignment of both eyes, followed by patching the healthy eye. However, due to the child's fear of impaired vision, the treatment was not properly followed, and the condition remained untreated. Later, at the age of 41, the patient underwent another surgery to realign her eyes, but no effort was made to treat the amblyopia. At the beginning of the current treatment, the patient's visual acuity was measured at 21/6.

Treatment Method: The patient declined conventional treatment methods, which are typically based on patching or limiting the vision of the healthy eye, due to the interference they caused with her vision and the importance of clear vision for her occupation. Her job requires long hours of continuous focus on carpets and paper patterns. The treatment method employed in this study aimed to provide a solution that would not disrupt the patient's vision based on her preference.

The functional system designed in this study pursued two primary goals: enhancing brain plasticity and retraining the brain to utilize the amblyopic eye. To increase brain plasticity, caffeine, a psychoactive

substance and a common daily consumable for many people, was chosen. Following the specialist doctor's instructions, the patient consumed one cup of Americano coffee daily, prepared with 70% Robusta and 30% Arabica beans.

To strengthen the vision of the amblyopic eye, the patient used the Amblyopia Play application for six months, five days a week, from Saturday to Wednesday, for 30 minutes each day. The patient consumed one cup of coffee at 10 a.m., 30 minutes before playing the game. On Thursdays and Fridays, she consumed one cup of coffee at 10 a.m. without playing the game. This process continued for six months.

Measured Variables: The measured variables included visual acuity, assessed using the Snellen chart, and visual clarity. Visual acuity was measured monthly by a specialist doctor, while visual clarity was evaluated daily through the Amblyopia Play application based on the patient's progress in the game. Additionally, at irregular intervals during the treatment, the patient's brain was scanned using an fMRI device by a specialist.

Discussion:

Summary of Results: The results obtained during the first week after the start of the experiment showed no changes. However, during the second week, a slight improvement in visual clarity was observed, indicating the brain's response to the new conditions. Additionally, during this week, for the first time, a brain scan of the patient was taken using an fMRI machine. The results obtained in the first month after the experiment began showed significant improvement in visual clarity and a reduction in the visual acuity score. The measured visual acuity registered 19/6, indicating a 0.2 score reduction since the start of the experiment. During the 16th week after the start of the experiment, a brain scan was taken again using the fMRI machine, and the resulting images showed increased activity in the V1 area in the occipital lobe of the brain. During the 19th week after the start of treatment, the previously consistent and gradual improvement in the treatment process was disrupted, and it continued at a much slower pace, remaining almost constant until the end of the treatment period. The results obtained from six months of continuous, uninterrupted treatment showed an overall improvement of 28.42% in visual clarity and a reduction in visual acuity to 12/6, indicating the effectiveness of this method.

Interpretation of Findings: The results obtained during the first week after the start of the experiment can be described as follows: in the patient's brain, concerning the neural networks related to the amblyopic eye, the inhibitory neurotransmitters of the GABAergic interneurons continue their activity, inhibiting the responses of the neurons in the visual area to light changes due to synaptic memory. The results obtained during the second week can be described as follows: the increased responsiveness of the brain to the treatment method indicates a reduction in the activity of inhibitory neurons and an increase in synaptic changes towards reducing attenuation and processing information. The results obtained from the first month after the start of the experiment can be described as follows: since the beginning of the treatment, the brain has been able to respond positively to the treatment method and begin interpreting messages from the amblyopic eye. The results obtained from the 16th week after the start of the treatment can be described as follows: this increased activity can be explained by the cessation of long-term attenuation in the cells related to the amblyopic eye. This increase in activity could be due to the reactivation of nuclear transcription of glutamate receptor genes, such as AMPA, which have not yet been turned off. In this week, the visual acuity score decreased to 16/6, and visual clarity showed a 20% improvement according to the Amblyopia Play application.
The results obtained during the 19th week after the start of the experiment can be described as follows:

the stabilization of neuroplasticity and the reduction of cell learning capacity led to a halt in the learning process for vision. At this stage, neurons, due to the reduction in long-term attenuation, regained their ability to regenerate and increased some of their receptors and neurotransmitters along with common synapses. This data can be justified by the fMRI results obtained in the 19th week. However, considering that many cells lost their gene expression ability and were unable to grow further, this process of improvement stopped.
The results obtained after 6 months from the start of the experiment can be described as follows: caffeine, as an indirect stimulant of dopamine secretion in the brain and as a psychoactive substance, was able to partially enhance neuroplasticity. During this period, the brain, using the targeted games in the Amblyopia Play program, was able to reactivate neurons related to the processing of the amblyopic eye and the neurons in the areas linking the vision of both eyes more actively than at the beginning of the experiment.

Comparison with Previous Studies: The results obtained from this treatment can be similarly observed in another experiment that examined the effectiveness of fluoxetine treatment in adult patients with amblyopia. In this treatment, which was a combination of occlusion of the healthy eye and the use of fluoxetine, patients experienced significant improvement in their vision during the first few months of treatment. However, after week 22 of the treatment, patients did not observe any further significant improvements in their vision. Additionally, in another experiment, a substance called levodopa, which stimulates dopamine production in the brain, was used. The results obtained from this experiment were consistent and nearly identical to those obtained from the current experiment.

Suggestions for Future Research: In order to fully understand the accuracy and effectiveness of this treatment method, it should be tested more comprehensively and extensively under more controlled conditions. It is also recommended that future experiments involve several specialists from various fields, including cardiologists, neurologists, and ophthalmologists, so that the patient's condition can be evaluated under different circumstances.

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Statement of Awareness of Publication:

After receiving complete information about the research objectives, methods, and potential outcomes, the patient consciously and with full consent expressed their agreement to participate in this study and the publication of its results.

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Author Contributions:
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