

The Color Photostimulation Impact on the Reproduction of Verbal Information

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Abstract: The article presents the results of a study on the prolonged effect of photostimulation in red, green, blue colors on the playback results (presented) of 10 words. The study involved 20 students, both genders, aged 19-20 years. Photostimulation was carried out in red, blue, and green colors at a frequency of 10 Hz for a duration of 5 minutes. The number of words reproduced without photostimulation and after stimulation with red, blue, and green was estimated. To identify the effect of imposing rhythm, an EEG was recorded. Statistical processing was performed using the Mann-Whitney U-test, using the SPSS program. Different colors showed different playback effects after 5, 10, 15 minutes. Blue color had the most positive effect, which was reflected in a significantly larger number of reproduced words at all stages of the study.

1. Introduction

Many areas of human activity, which include education, are excessively saturated with informational load and its significance. For example, for successful learning, students need to process, analyze, and remember a large amount of new information. At the same time, the main load falls on the central nervous system (CNS), its functional state, which can (for many reasons) deviate from the optimal level, which requires the use of corrective measures in order to ensure productive activity.

Known methods for correcting the functional state of the central nervous system include stimulation of visual and auditory analyzers, aimed at the targeted formation of a certain level of brain activity through audio-visual stimulation with a particular frequency [1, 3, 5, 6, 7, 12].

A change in the bioelectric activity of the cerebral cortex in response to stimulation in a selected frequency range leads to the formation of a given functional state of the central nervous system [1, 3, 9, 12].

Earlier, in our studies, it was shown that the use of the method of color stimulation allows optimizing the functional state of students, which leads to an improvement in indicators of attention and memory [4, 9, 12]. However, it was unclear how delayed this effect is and how different colors of stimulation affect this process. It is well known that red, green, and blue colors have different effects on the functional state of a person [8]. The aim of this study was to evaluate the prolonged effect of the effects of photostimulation in different colors on the reproduction of verbal information.

2. Materials and Methods

A total of 20 students (girls and boys) aged 19-20 years old took part in the experiment. Each participant once listened to a series of 10 unrelated words that he/she had to remember and then played them immediately after listening, as well as after 5, 10, and 15 minutes. For photostimulation, the GSPI-1Ts apparatus was used, including darkened glasses with LEDs on the inside and a control unit with which the frequency and color of the flickering LEDs are set. Color photostimulation (CFS) was carried out in red, blue, and green colors at a frequency of 10 Hz for 5 minutes. This frequency was chosen in connection with our earlier data, indicating that the dominance of alpha activity in the background EEG in the range of 9.9-10.11 Hz is optimal for mental activity [4].

The bioelectrical activity of the brain was recorded by "Encephalan 131-03", a 21-channel computer electroencephalograph ("Medicom," Russia). The dominant frequency of the primary rhythms of the electroencephalogram (EEG) was determined. The basis for this approach is not the mechanisms of local (more related to the content of activities) but generalized (more determining the functional state of the body) brain activation by non-specific structures of the central nervous system.

The number of reproduced words without color effects, and also after stimulation with red, blue and green, was estimated. To assess the functional state of the central nervous system, the EEG was recorded using a 21-channel "Medicom 131-03" electroencephalograph. Statistical processing was performed using the Mann-Whitney U-test, using the SPSS program.

3. Research Results

The analysis of the obtained results revealed a significantly ($p < 0.05$) greater number of reproduced words immediately after their presentation, after 5, 10, and 15 minutes when exposed to green and blue, in comparison with the results of experiments without photostimulation (Tables 1-4).

Thus, in the direct reproduction, subjects recalled 15% more words with CPhS in green color and 21% in blue color. 5 minutes after the presentation of the words, the subjects recalled 10% more words with CPhS in green and 21% in blue. After 10 minutes, there were 11% in green and 21% in blue. After 15 minutes - 13% in green and 19% in blue. When photostimulation in red, no significant changes in the reproduction of the presented words were found.

TABLE 1. STATISTICALLY SIGNIFICANT DIFFERENCES IN THE NUMBER OF REPRODUCED WORDS IMMEDIATELY AFTER CPhS

Comparison of effects	Average values	p
No exposure and CPhS in red	7.35 and 7.75	0.04
No exposure and CPhS in green	7.35 and 8.60	0.002
No exposure and CPhS in blue	7.35 and 9.35	0.0000005
DFS in red and CPhS in green	7.75 and 8.60	0.005
DFS in red and CPhS in blue	7.75 and 9.35	0.00001
DFS in green and CPhS in blue	8.6 and 9.35	0.03

TABLE 2. STATISTICALLY SIGNIFICANT DIFFERENCES IN THE NUMBER OF REPRODUCED WORDS IN 5 MINUTES AFTER CPhS

Comparison of effects	Average values	p
No exposure and CPhS in red	6,45 и 7,00	0,04
No exposure and CPhS in green	6,45 и 7,20	0,02
No exposure and CPhS in blue	6,45 и 8,15	0,000006
DFS in red and CPhS in blue	7,00 и 8,15	0,002
DFS in green and CPhS in blue	7,20 и 8,15	0,02

TABLE 3. STATISTICALLY SIGNIFICANT DIFFERENCES IN THE NUMBER OF REPRODUCED WORDS IN 10 MINUTES AFTER CPhS

Comparison of effects	Average values	p
No exposure and CPhS in green	6.35 and 7.10	0.01
No exposure and CPhS in blue	6.35 and 8.05	0.000009
DFS in red and CPhS in blue	6.60 and 8.05	0.0004
DFS in green and CPhS in blue	7.10 and 8.05	0.01

TABLE 4. STATISTICALLY SIGNIFICANT DIFFERENCES IN THE NUMBER OF REPRODUCED WORDS IN 15 MINUTES AFTER CPhS

Comparison of effects	Average values	p
No exposure and CPhS in green	6.45 and 7.40	0.003
No exposure and CPhS in blue	6.45 and 7.95	0.00005
DFS in red and CPhS in green	6.45 and 7.40	0.01
DFS in red and CPhS in blue	6.45 and 7.95	0.0002

The EEG registration showed a significant ($p < 0.05$) change in the alpha rhythm frequency from 9.52 Hz to 9.95 Hz after photostimulation, as well as a significant ($p < 0.05$) increase in the beta rhythm frequency from 15.70 Hz to 17.68 Hz. Changes in the alpha range were due to the effect of imposing frequency on DFS, which simultaneously affected the beta rhythm of the EEG.

TABLE 5. MEDIUM-GROUP VALUES OF FREQUENCY OF ALPHA AND BETA RHYTHMS OF EEG AFTER CPhS

EEG rhythms	Frequency value to CPhS	Frequency value after CPhS	p
Alpha rhythm	9.52	9.95	0.005
Beta rhythm	15.70	17.68	0.009

4. Discussion

Earlier, we showed that 10 Hz photostimulation has a positive effect on mental performance and memorization [4, 9, 12]. It is known that during stimulation in the range of the EEG alpha rhythm, the subjects show positive changes in the level of situational anxiety, well-being, activity, mood, the level of neuropsychic tension decreases, and the state of the body's regulatory systems normalizes [5, 10, 12].

O. M. Bazanova suggests [2] that the alpha rhythm reflects the reverberation of excitations encoding intracerebral information and sets the optimal background for receiving and processing incoming signals. The role of the EEG rhythm of this range consists of the functional stabilization of brain states and providing readiness to respond to stimuli. This can explain both the results known from the literature and the positive changes obtained in this work in mental states, processes, and functions. The works of J. Williams [11] prove that photostimulation with a frequency of 10 Hz positively affects the processes of memorization and reproduction of information.

The results obtained in this study found that during photostimulation with a frequency of 10 Hz, the greatest effect (both direct and prolonged) of the reproduction of the presented words was observed when exposed to blue. This happened in the context of a change in the functional state of the brain in the direction of increasing its activity.

5. Conclusion

In the course of this study, it was found that, in addition to the frequency of stimulation, the color by which the effect is carried out has a great influence on the results of the reproduction of 10 presented words. The colors used showed different effects of the reproduction of words after 5, 10, 15 minutes. Blue color had the most positive effect, which was reflected in a more significant number of reproduced words at all stages of the study. The results can be used to optimize the memorization function in individuals whose activities are based on the perception and processing of a large amount of verbal information. In the future, it is planned to study the duration of the prolonged effect.

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