A NEUROSCIENTIFIC RESEARCH OF HOW COLOR AFFECTS COGNITION AND PERCEPTION

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Today as the neurology is performed different ares, it is used in various science fields. In the analysis of the individual's decision-making processes, the classical methods are preferred as well as the experimental methods. These methods arouse mostly in the marketing sector as neuromarketing and they have also been used in other disciplines.

It's observed that the individuals make decisions according to the obtained results by summing up the irrational and rational data regarding their choices. When these decision-making processes are being observed, it's seen that according to the data obtained by measuring their neurological and physiological reactions, the emotional choices, tastes etc. of the people can be concretized.

In the light of this information, the studies were performed in different disciplines and many results were presented. It's considered that these performed studies will contribute a lot to the neuro-interdisciplinary field and it will bring different point of views to the literature. Thus, in this study, brain waves of the people were observed by EEG device and the data was assessed.

The study is based on exploratory experimental methodology. An experimental environment far from the influences has been created without giving any information previously to the subjects in an independent fiction. In this study, by asking preliminary questions, the volunteer's solving skills, complexity – color relationship, pattern-color correlation, the influence of the main colors (red, blue and yellow), black and grey on solving skills, gender - solving skills, difficulties related to gender – color correlation have been analyzed.

By showing the questions used in the Visual-Spatial Aptitude evaluation in 12 slides, each for 10 seconds, to the participators, it was requested from them to focus on the answer that is right for them and to say it loud. At the same time with the slideshow, participators' EEG data has been recorded. Additionally also their emotional status has been monitored with the camera.

10 students easily selected as subjects with the easy sampling method study in The Çankaya University. The sampling group consists of both male and female 3rd and 4th grade interior architecture students, between the ages of 20 and 26.

When the results were evaluated, it's observed that the subjects solve the questions with the white background more easily. When the same question was asked on the same background to the participants, they mostly gave right answers to the questions consisting of colored shapes. It was observed that the right answer rate has been decreased for the questions consisting of grey colored shapes. It's observed that the male participators perform a lower brain activity regarding the questions in general. The related data results have been described with the tables.

Although the research results were given in Ankara, the majority of the sampling group consists of the students who grew up out of Ankara City. Thus, the research results can be only generalized for these students and for these questions. However, the study can be revised according to other age groups, social status and other demographic features and a more comprehensive generalization can be made.

Keywords: Neuroscience, EEG, visual spatial aptitude, cognition, perception

Human brain and the nerve system, plays a relevant role in defining the presence and location of the objects and recognizing the objects. Color and light are the most important factors in the recognition. Perception is the general description of the human's acquisition, recognition, understanding of the cases, qualifications and relations and

getting in contact by their sense organs. The perception appears to be the subtitle of cognition. The cognition is a whole with perception, attention, memory, idea and language.

Every human perceives the environment by establishing different relationships and it's directly related to the cognition how he/she perceives it. The people have different intelligence types and their intelligence form their lives. Cognition and perception are directly related with these intelligence types.

The Harward University Professors, Mr. Howard Gardner, describes the multiple intelligence consisting of 8 intelligence types that he has revealed in 1983 as "the capacity of making useful things for the society; all the unique skills and abilities found in every human". Together with the last element that Gardner has added in 1997, 8 intelligence powers are; Linguistic – Language Logic – Mathematical, Shape (Visual) (Spatial; Areal) – Space, Musical – Rhythmic Physical – Kinesthetic, Interpersonal – Social, Person Oriented (Internal; Self Oriented), Nature (Gardner,1999).

Multiple Intelligence Theory-Visual-Spatial Intelligence (Visual-Spatial)

This area deals with visual-spatial judgment and visualization capabilities through the eyes of the mind. The ones who have this type of intelligence are suitable for the professions such as acting, designing and architecture. It's observed that the people who have spatial intelligence are also good at puzzle games. The point where looking and seeing gets separated, visual / spatial intelligence comes into play. The visual /spatial intelligence seen predominantly in artists, architects helps to perceive the visions different than the others and to express the perceptions graphically. Visual intelligence is the skill to perceive the world in the right way, to make modifications and transformations on the initial perception, to reproduce the visual experience even in the absence of the physical stimulant. (Saban,2001).

The main function of the spatial intelligence is dreaming. Understanding the non verbal definitions, seeing the objects from different angles, capturing the things without the physical stimulus are the skills of this field. (Gardner,1999)

According to Talu, this kind of intelligence area, consists of the monitoring and displaying skills of visual and spatial ideas graphically and objectively of an individual. (Talu, 1999).

Every individual has many different intelligence areas. Multiple intelligence theory is to embrace that every individual has the skills in all the intelligence areas instead of determining only one type of intelligence in humans. However, these above-mentioned intelligence areas are found in different levels in each individual.

Every individual can develop all of these various intelligence areas up to a sufficient level. Multiple intelligence theory suggests that actually every individual has the ability to improve the intelligence areas at a pretty high level when sufficient and adequate support is given and when the opportunity and education are provided (Gardner,1993).

Meanwhile, Kimura has analyzed the spatial ability in six dimensions. These are; spatial orientation, spatial location memory, targeting, spatial visualization, object differentiation and spatial perception ability (Kimura, 1999). When the dimensions expressed by the researchers are analyzed, three dimensions seem to forefront. These are;

Spatial Orientation: It's the ability to predict accurately the future variations in the appearance of the object, as a result of moving the object in a particular direction. This ability can be determined by the tests measuring the view of two or three dimensional new objects with their movements at different angles in the two and three dimensional space. (Kimura, 1999).

Spatial Visualization: It's the ability to notice the changes of the direction occurred in the scene and to determine the amount of this change. This ability may be compared to the mental rotation skill, the spatial visualization skill requires the prediction of the relationship between the dynamic and statistical views of an object. In addition, the spatial visualization skill can also be described as the revitalization of the two dimensional status of a three dimensional object (just like the open version of a cube). (Kimura, 1999).

Mental Rotation: It's the ability to rotate the shapes in mind and to determine the status of the shape in the space according to the indicated object or situation. (Kimura, 1999).

Visual-Spatial Aptitude Test

Visual-Spatial Test Method used during the research has been released as a result of the Multiple Intelligence Theory suggested by Gardner.

Based on Gardner's and Kimura's thesis which defends that the visual-spatial intelligence can be improved, in terms of the internal architecture education that the students had, they were expected to have improved skills and the

perception and cognition of colored and grey scale shapes with different background colors will be tested by using spatial visual aptitude test which is one of the evaluation criteria of the recruitment strategy of many important companies.

Neuro-Scientific Test

The method to write the potential changes a bit different then the evoked status related to the receptor activities or continuous rhythmical electrical potential changes, occurred spontaneously during the brain activity with the help of the electrodes placed around the skull is called Electroencephalography (EEG). EEG (Electroencephalography) shows differences related to the age, brain's alertness status, emotional stimulants, brain diseases, drugs and the chemical changes in the body. (Daşdağ, 2008)

Brain activity waves measured by EEG;

• Theta waves: These waves whose frequencies are between 4-7 Hz, and amplitudes are between 5-100 µV are seen in normal individuals when they are dreaming in their sleeps, when the brain is in low activity status such as being under moderate anesthetic status and when they are under stress. Theta waves are powerful during self-oriented focusing activities, prayers and spiritual awareness, they are observed in the subconscious status.

• Alfa waves: These waves whose frequencies are between 7-13 Hz, and amplitudes are in interval 2-10 µV are close to sinusoidal manner. It's seen when the individuals' eyes are closed although they are awake, there are no external stimulants and they are physically and mentally at complete rest. It can be seen well on the records taken from the occipital area.

• Beta waves: These waves whose frequencies are greater than 13 Hz, and amplitudes are between 1-5 µV are seen during the phases of focused attention, mental work, rapid eye movement in the sleep and sensory information processing. It's the highest activity level of the brain. (Demirkazık 2014).

In this study EEG method was used. EEG analysis was compared and the result was evaluated. EPOC+ Emotiv EEG device with 16 channels was used. The analysis was interpreted by using Test-bench and 3D brain map software.

The Visual-Spatial Aptitude Test questions given in totally 12 slides, were interpreted with the EEG data tables related to these answers and right answers given by the participators.
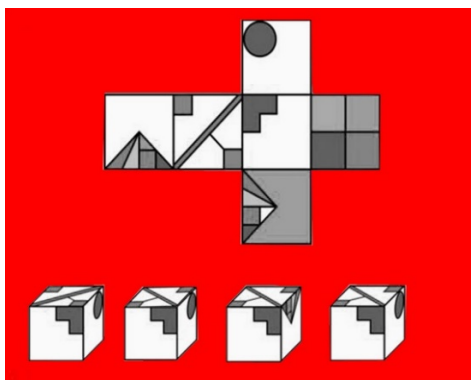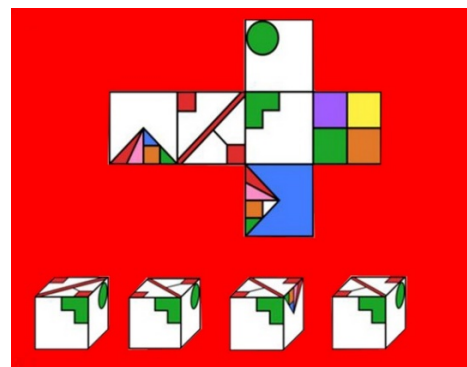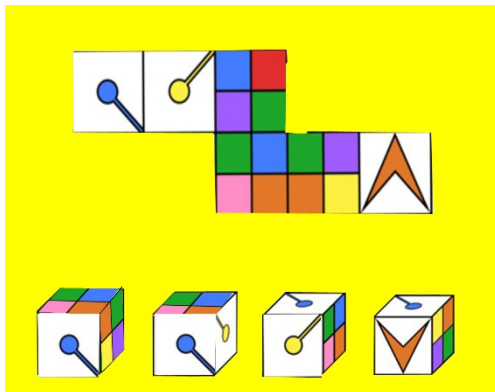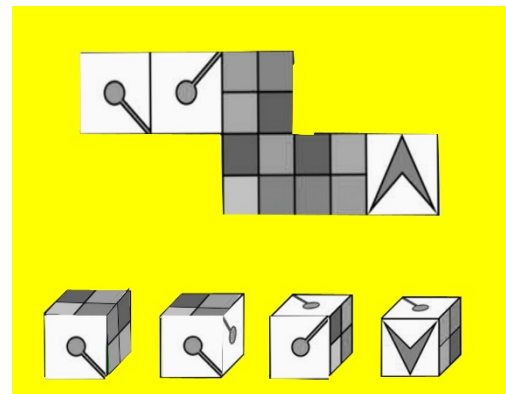

Slide 1

Slide 4

Slide No	Right Answer %	Color of the shape	Background	Number of Empty Answers	Most Given Wrong Answer	Rate of The Wrong Answer Given Mostly %	Dominant Activity Level	Wave Length Range	Focused Area in Activity
1	20	Grey	Red	4	3	50	Low	Beta	Right Frontal
4	10	Colored	Red	3	3	83	Medium	Beta	Left-Right Frontal, Right Temporal

The 1st and 4th questions, where the background is red and the shape is colored and grey, seem different but actually they are the same questions. Right answer has been given to the 1st question by %20, where background is red and the shape color is grey. The rate of the right answer decreases to %10, when the background was in red and the shape was colored. The contributors have considered the 3rd answer, which was among the wrong answers as a right answer in the second slide and they have chosen it. 3rd option was the most preferred answer. The rate of choosing this option increased in the third slide. Generally the brain activity level of the participators is low or medium. In the answers given by the participators to these questions, Beta wavelength range were observed; an activity has been noticed in the right and left frontal parts and right temporal of their brains.
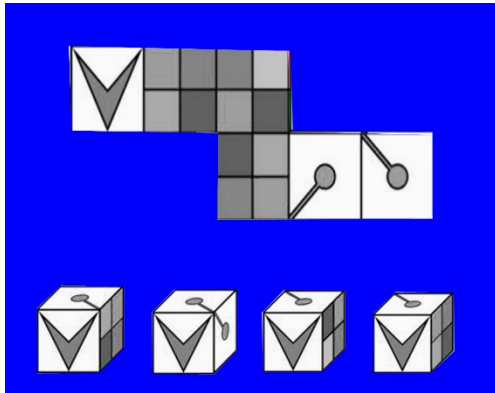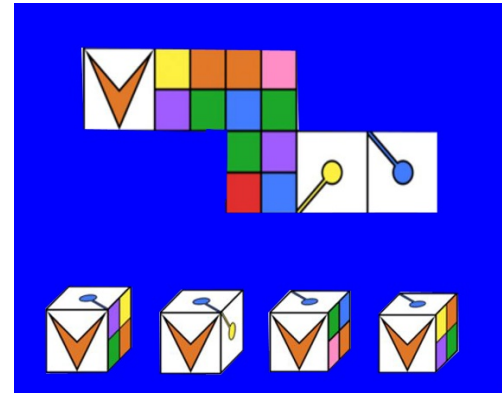

Slide 2

Slide 7

Slide No	Right Answer %	Color of the shape	Background	Number of Empty Answers	Most Given Wrong Answer	Rate of The Wrong Answer Given Mostly %	Dominant Activity Level	Wave Length Range	Focused Area in Activity
2	20	Colored	Yellow	1	3	43	High	Beta	Right Frontal
7	10	Grey	Yellow	2	2	63	Very Low	Beta	Right Lob

The 2nd and the 7th questions were modified with a yellow background, grey and colored shape. In the 2nd question, the answer was given %20 right when the question was colored, however it decreased to %10 when the shape was changed into grey. When the shape was colored, %43 of the participators chose the wrong option, which was the 3rd option, when the shape was changed into grey, %63 of the participators chose the wrong option which was the 2nd option. The people who gave the right answers to the questions shown one after another in 10 seconds, were less. In general, the reaction level that the participators had for the colored shape on the yellow background was a high level in the Beta wavelength range (22-28Hz). The activity level decreased when the shape color has been changed into grey.
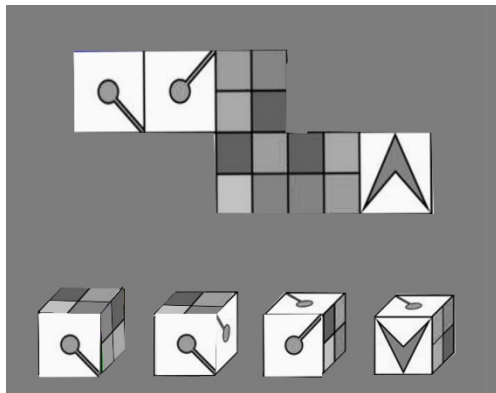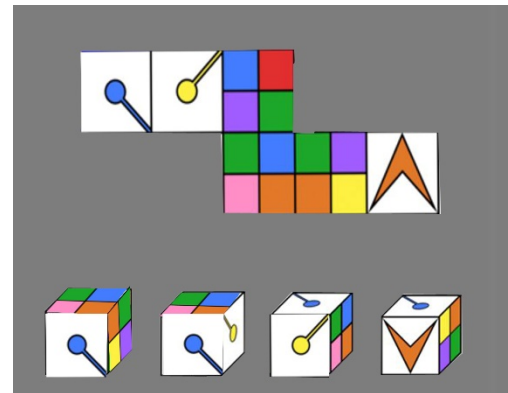
Slide 5

Slide 10

Slide No	Right Answer %	Color of the shape	Background	Number of Empty Answers	Most Given Wrong Answer	Rate of The Wrong Answer Given Mostly %	Dominant Activity Level	Wave Length Range	Focused Area in Activity
5	20	Grey	Blue	1	1	50	Low	Beta-Alpha	Right Frontal
10	40	Colored	Blue	0	3	43	Low	Beta-Alpha	Right Lobe

The 10th question on the 10th slide had a blue background and a colored shape. %40 of the participators answered this question accurately. It was observed that the correct answer rate decreased to %20 when the shape has been changed into grey. In the 10th and 5th questions with the blue background, it was observed that the brain activities of the participators decreased (7-9 Hz Alpha, 15-18 Hz Beta). Activity level was low in general. In the participators, Alpha and Beta wavelength weren't screened in general. The wrong answers chosen mostly by the participators were the 1st option in question 5 and 3rd option in question 10. It's observed that the participators referred to the wrong answer in the question with the grey color and that these rates increased.
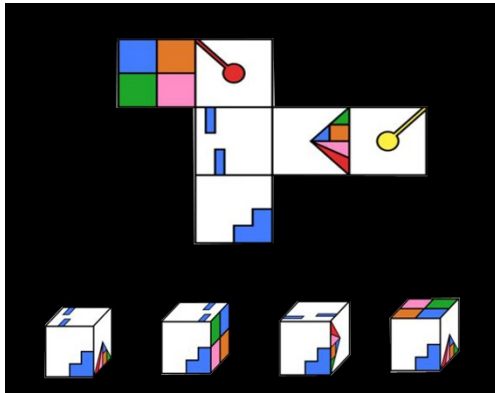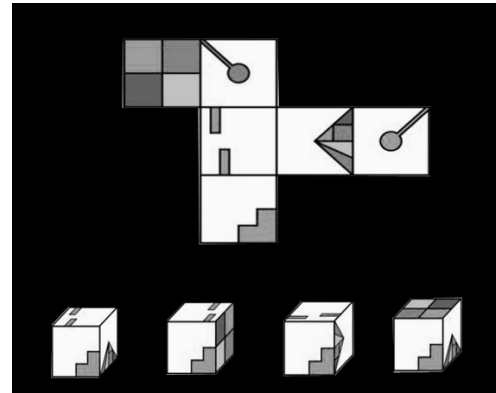
Slide 3

Slide 6

Slide No	Right Answer %	Color of the shape	Background	Number of Empty Answers	Most Given Wrong Answer	Rate of The Wrong Answer Given Mostly %	Dominant Activity Level	Wave Length Range	Focused Area in Activity
6	0	Colored	Grey	1	2	56	Medium	Beta-Alpha	Right Lobe
3	10	Grey	Grey	3	1	50	Low	Beta	Right Frontal

The 6th and the 3rd question had the same shape. In these questions, grey background was used. It's seen that the participators didn't give the right answer to the questions with the colored shape on the grey background. %56 of the participators had the tendency to choose the 2nd option as an answer, which was a wrong answer. It's seen that the brain activity level of the participators are mostly at a medium level (9-11Hz Alpha, 18-22Hz Beta). An activity was observed on all the electrodes attached to the right lobe of participators' brains. The 3rd question was a question with a grey shape on a grey background. It's observed that %10 of the participators gave the right answer to this question. There was a decrease in the brain activities of the participators, (15-18Hz Beta) it was observed that the brain activity was intense in the right frontal part.
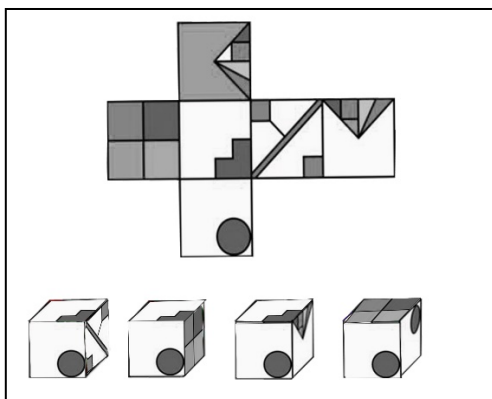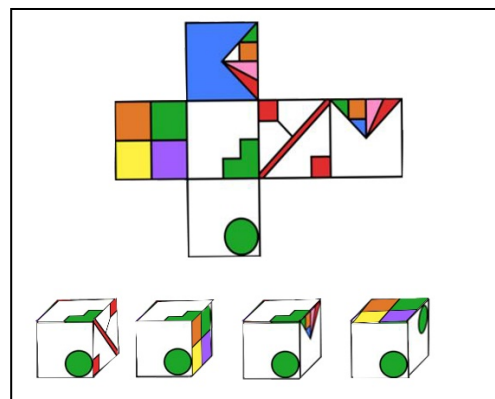
Slide 8

Slide 12

Slide No	Right Answer %	Color of the shape	Background	Number of Empty Answers	Most Given Wrong Answer	Rate of The Wrong Answer Given Mostly %	Dominant Activity Level	Wave Length Range	Focused Area in Activity
8	20	Colored	Black	1	2	71	Low	Beta	Right Frontal
12	50	Grey	Black	0	4	60	Medium	Beta	Right Frontal, Front Right Frontal

In the 8th and 12th questions a black background was used. It's seen that %20 of the participators gave the right answer to the question with the black background and colored shape. %71 of the participators, leaded to the wrong answer found in 2 choices with the assessment of the right answer. Low activities were observed on the right frontal part of the participators (15-18Hz Beta). When the color was changed into grey, %50 of the participators gave the right answer. It's observed that the wrong answer in the 4th option has been chosen by %60 of the participators. It's observed that the brain activity level of the participators is at a medium level in general (18-22 Hz Beta).

Slide No	Right Answer %	Color of the shape	Background	Number of Empty Answers	Most Given Wrong Answer	Rate of The Wrong Answer Given Mostly %	Dominant Activity Level	Wave Length Range	Focused Area in Activity

Slide 9

Slide 11

Slide No	Right Answer %	Color of the shape	Background	Number of Empty Answers	Most Given Wrong Answer	Rate of The Wrong Answer Given Mostly %	Dominant Activity Level	Wave Length Range	Focused Area in Activity
9	50	Grey	White	3	0	0	Medium	Beta-Theta	Right Frontal
11	70	Colored	White	0	0	0	Low	Beta	Right Frontal

The 9th and 11th questions consisted of grey and colored shapes on white color. When the background was white and the shape was grey, it was observed that %50 of the participators answered accurately to the question. When shape was colored, it was observed that %70 of the participators answered accurately to the question. The right answer rate decreased when the question was changed into grey. The highest answer rate was on the question with the white background and colored shape. To the other questions max. %50 of the participants in general gave the right answer. Usually, low and medium Beta and Theta waves were observed in the participators during the questions asked on the white background. These activities were observed on the Right Frontal part of the participators.

1	20	Grey	Red	4	3	50	Low	Beta	Right Frontal
4	10	Colored	Red	3	3	83	Fair	Beta	Left-Right Frontal, Right Temporal
2	20	Colored	Yellow	1	3	43	High	Beta	Right Frontal
7	10	Grey	Yellow	2	2	63	Very Low	Beta	Right Lobe
5	20	Grey	Blue	1	1	50	Low	Beta-Alpha	Right Frontal
10	40	Colored	Blue	0	3	43	Low	Beta-Alpha	Right Lobe
6	0	Colored	Grey	1	2	56	Medium	Beta-Alpha	Right Lobe
3	10	Grey	Grey	3	1	50	Low	Beta	Right Frontal
8	20	Colored	Black	1	2	71	Low	Beta	Right Frontal
12	50	Grey	Black	0	4	60	Medium	Beta	Right Frontal, Front Right Frontal
9	50	Grey	White	3	0	0	Medium	Beta-Theta	Right Frontal
11	70	Colored	White	0	0	0	Low	Beta	Right Frontal

When the results were evaluated in general, it's observed that the participators solve the questions with the white background more easily. When the same question was asked on the same background to the participants, they mostly gave right answers to the questions consisting of colored shapes. It was observed that the right answer rate has been decreased for the questions consisting of grey colored shapes. It was observed that the male participators perform a lower brain activity regarding the questions in general. During the analysis of the EEG data, an activity on the frontal area, which is effective in decision-making process, has been observed while the participators were answering the questions. Usually, medium and low level of activity was observed in The Beta frequency. Beta frequency is mostly in a normal rhythm. It's the dominant rhythm when external and internal stimulants increase or in case of anxiety. The presence of Beta rhythm was normal because the participators' eyes were open during the EEG test. Between the Beta rhythm of 12- 15 Hz, the person is comfortable and focused. The participants are alert, active and peaceful between 15-18 Hz. The participants in this range of brain wavelength, can increase the mental abilities and focus on by increasing their brain activities. Over 18 Hz, the activation can be increased in a harmonious way by integrating the mind and the body. Participants demonstrated a serious condition of alertness enough to cause anxiety because they didn't have an exact information about the correct answer. It's observed that when the participators were close to the right answer, their brain activities were decreasing (Sürmeli 2010).

In %30 of the participators, it's observed that the brain activity is in the Alpha Frequency during the solution of the questions. It's determined that these questions' background colors were in blue and grey. Alpha Frequency was between 7- 13 Hz. In the Alpha frequency, it's monitored that the participants' relaxing feeling increased and they had more mental skills and harmony and they were close to the right answers. During the Alpha Frequency it's observed that the people come to the conclusion of a creative problem. In the low Alpha Frequency, the people were confident, relaxed and they had internal awareness (Sürmeli 2010).

The status of concern, anxiety, irritability and shyness has been observed during the theta wave perception and the cognition afterwards.

In

Sex	Number of Right Answers	Number of Slides	Brain wave length range			Activity level				
			Beta	Alfa	Theta	FAIR	HIGH	VERY HIGH	LOW	VERY LOW
Female	20	12	13	5	2	4	6	*	10	*
Male	11	12	8	3	*	3	2	1	3	2

general, it's observed that when the participators find the right answer, their brain waves decrease. Mostly the right answer was given to the question with the white background.

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