RESEARCH PAPER

# Determining the Relationship Between Cognitive Performance and LED Lamp Color Temperature and Personality Type in Students

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## ABSTRACT

*Background: The lighting of the work environment and its quantitative and qualitative characteristics, such as the intensity of the light and the color temperature, as a physical characteristic, have a great impact on the mental health, behavior and performance of people. The physical factors of the work environment, the personality type and behavioral characteristics of people are effective in their efficiency and productivity. Methods: The current research is an interventional and laboratory research which was done in 2022, 35 male students of Tarbiat Modares University were studied. This study was designed in 3 locations with different lighting systems of LED lamps with color temperature of 3000, 4000 and 5000 degrees Kelvin. Stroop test software was used to check cognitive activities and Neo questionnaire was used to determine personality type. Results: The results showed that the average reaction time when facing the LED lamp with a color temperature of 4000 degrees Kelvin in the group of consonant words was the lowest (average response time 601.22 milliseconds) and at a color temperature of 3000 degrees Kelvin in the group of dissonant words the highest value (average 88. 645 milliseconds). The average number of errors in the group of dissonant words was the highest when faced with a color temperature of 3000 degrees Kelvin (the average number of errors was 10.8), the lowest amount of errors was observed in the group of consonant words at a color temperature of 5000 degrees Kelvin (the average number of errors was 2.71 ). Also, according to the obtained results and checking the interference score of the people, which shows the level of their selective attention, it was found that the average interference score at the color temperature of 3000 degrees Kelvin is the highest (average 6.05) and when faced with the color temperature of 4000 degrees Kelvin The lowest value was (average 4.14). The results of investigating the relationship between cognitive activities and the personality type of the subjects studied at different color temperatures showed that there was a negative and significant correlation between the interference score of the personality type of the subjects at a temperature of 3000 degrees Kelvin (P value = 0.33). Also, by examining this relationship at a color temperature of 5000 degrees Kelvin, it was found that there is a negative and significant correlation between the interference score and the interference time (another parameter affecting selective attention) with the personality type of people (P value = 0.42 and 0.38, respectively). = P value) Conclusions: The results of this study showed that the LED lighting system with high color temperature can be effective on people's cognitive performance by reducing errors and increasing attention and reaction time. In order to improve people's cognitive performance, it is suggested to use lighting system with high color temperature in sensitive places.*

**KEYWORDS:** *Color temperature; Brightness; Personality type; Cognitive function.*

## 1. Introduction

The work that humans do has changed from physical work to monitoring work, solving problems and making decisions in the creation system. In fact, today's society can be said to function safely and relies on numerous technical systems in various sectors of industry, transportation, communication, energy resources, information, materials, health, and economy. Cognitive ergonomics deals with the practical issues of the use of humans and technology in the work environment, especially on the impact and effectiveness of the cognitive system of humans and work and working conditions. Ambient lighting is considered one of the most effective external factors affecting the cognitive

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mechanisms of the brain. Improper quality and quantity of light can cause various complaints such as eye fatigue, headache, visual impairment, eye gaze disorder, physical fatigue and psychological effects. It is also effective on the occurrence of accidents such as the fall of people, objects, and human errors [1]. Human error is one of the important factors in the occurrence of accidents and also as a disruptive factor in the planned operation of systems [2].

Recent studies have investigated the non-visual effects of light on cognitive processes and mood regulation, and the results showed that exposure to light has positive effects on alertness and mood, and also increases productivity at work.

Studies have shown that different values of brightness intensity and color temperature, as two very important criteria in lighting, create different mental and psychological effects in people [3].

Correlated Color Temperature or CCT is one of the important characteristics of lighting in the indoor environment, and it has attracted significant attention in the sense that it affects biological and psychological processes in humans. The color temperature expresses the ability of the source to emit the color spectrum at which the black body emits that spectrum, which is expressed in degrees Kelvin. [4]

In the study of Ruta Lasauskaite et al., it was found that Correlated Color Temperature has a relatively large blue spectrum in its components, and it has been found that people are more alert in this lighting condition [5]. The results of examining color temperature on cognitive activities in Yingying Zhu et al.'s study also showed that when exposed to warm light, people are significantly more accurate than cold light. The processing speed or reaction time of people facing high color temperature was significantly higher than the temperature of 3500 degrees Kelvin. In terms of alertness, people performed better when faced with high color temperature of light compared to light with low color temperature.

Paying attention to the job and job activities from its psychological aspect and not from the social or economic aspect, has occupied the mind of psychologists for a long time because it is possible to predict people's behavior through personality traits and match the personality Individuals with working conditions increased their efficiency in job fields. [6]

In examining people's mental and psychological activity or performance, indicators are used to show their cognitive status, reaction time and attention index are the most important of these indicators [7]. Reaction time (RT) is the time interval between the unexpected presentation of the stimulus and the start of the response, and it is one of the important decision-making factors and indicates the speed of information processing (IP). Attention is also a cognitive process that is defined as a selective focus on one aspect of the environment, while other aspects are ignored [8]. Selective attention is the ability to process relevant information and data while rejecting false or irrelevant data. A common solution to investigate selective attention is to see how participants respond to a target stimulus in the presence or absence of error-causing factors. Usually, the error-causing factors have a different answer from the target answer, and their involuntary processing interferes with choosing the right answer. This inconsistency of responses must be resolved before the final response, and as a result, this causes relatively poor performance (slower response time, or more errors) [8]. In the studies conducted in the field of lighting, mostly the quantitative aspect of lighting has been considered, and different characteristics of light, including the effect of light color temperature on cognitive activities, have been less investigated. If a change in any of the lighting variables may lead to a change in any of the stated effects on cognitive activities.

Personality type is expressed as characteristics of temperament, thinking, and even physical characteristics of a person that are more or less fixed and stable that determine unique adaptation to the environment. [9]

Based on previous studies, lighting is considered as the main parameter affecting people's understanding, processing and cognitive performance, but as mentioned before, in the design of internal and external lighting systems, as well as in the studies conducted in the field of lighting, usually the qualitative parameters of the lighting system, less attention is paid and generally the emphasis is on quantitative parameters of light. In this study, in order to design lighting in different colors, lamps with equal power and 9 watts were used in specific color temperature (3000, 4000, 5000 degrees Kelvin). In order to determine the accuracy and intensity of the light, the Lux meter device was used and considering that the power and model of all three types of lamps used in the study were the same and the height of their placement was also the same, the intensity of their brightness was also the same and could not be except variable. Tests should be raised. However, the light intensity was measured with the mentioned device and its level was 250 lux in all three tests.

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Due to the fact that a few studies on the relationship and impact of personality characteristics on cognitive characteristics have been investigated. [8]. And most of the studies have been done on the effect of environmental factors on selective attention and reaction time, as well as the combined effect of harmful factors of the work environment with personality type on individual performance. Therefore, it is necessary to investigate other environmental factors on people's cognitive activities. Considering that LED lamps are widely used as common lighting in various industries and these lamps offer higher efficiency and lifespan than conventional fluorescent technologies, and considering the non-visual effects of light and the importance of these effects on cognitive performance and the effect of personality traits on people's activities and cognitive performance, the present study was conducted with the aim of determining the relationship between LED lamp color temperature and personality type on students' cognitive activities.

## 2. Literature Review

Based on the study by Feltrin et al. in 2020 with the aim of investigating the Impact of Illumination Correlated ColorTemperature, Background Lightness, and Painting Color Content on Color Appearance and Appreciation of Paintings, they concluded that lighting design for art exhibitions has a significant impact on enjoyment and understanding.

Of the displayed works of art in particular, the choice of light sources and the design of the museum space affect the visitors' visual perception of the works of art and their color appearance. This project investigated some of the potential factors—the relative color temperature (CCT) of the illuminance, the overall color content of the painting, and the lightness of its background—that affect the appearance of color and the perception of a painting.

The museum setting of this study included a survey conducted in the laboratory with both naïve subjects

Light observers and experts. The CCT of the light was found to be the main factor influencing the appearance of the painting and the observers' overall preference for lighting arrangements, while the overall color content of the painting and the background luminance had minor effects. Furthermore, perceived brightness has been found to increase with CCT. [10]

According to the study by Habibi et al., which was conducted in 2021 with the aim of Investigating the Combined Effects of Heat and Light Color Temperature on Precision and Speed in Female Students in Laboratory Conditions, they found that cognitive functions, such as accuracy and speed, It significantly affects human errors and accidents. Bright color temperature and heat can affect cognitive functions. And their research has investigated the effect of heat and color temperature on the speed and accuracy of work in the laboratory.

This study was conducted on 10 female students in the laboratory of the medical school of Isfahan University of Medical Sciences in Isfahan city. Piron vibrometer and precision and target vibrometer were used to measure accuracy and speed.

In general, the results of their study showed that the working accuracy at 36°C is lower than when exposed to 22°C. The work speed is faster and changing the light color temperature does not have a significant effect on increasing the work accuracy. Therefore, they suggested to use control solutions to reduce the temperature in environments with higher temperature than comfort. [11]

According to the study of Li Lan and colleagues in 2021 and with the aim of investigating the effects of light illuminance and correlated color temperature on mood and creativity, they found that the lighting environment is one of the factors of the indoor environment that may affect creativity.

The combined effects of illumination (300 lx vs. 2000 lx) and color temperature (3000 K vs. 6000 K) on mood and creativity were investigated in 24 participants. During exposure, participants completed questionnaires to assess their mood and light perception, performed creative and analytical tasks, and collected saliva samples for analysis of melatonin concentrations. The interactive effect of brightness and color temperature on mood was observed. Participants expressed higher positive mood (at 2000 lx, 6000 K and 300 lx, 3000 K) and better performance on the occlusion resistance task when they performed better on flexibility, fluency, and originality skills in the creative verbal task. In figural creative work, they reported the least.

Positive mood (at 2000 lx, 3000 K). Analytical thinking, including calculation and echoic memory skills, were facilitated in the light setting (300 lx, 6000 K) that induced the least emotional intensity.

No significant difference was observed in melatonin concentration. This evidence suggests that the emotional state of the occupants was

affected by the light and their creative performance was affected and changed accordingly. These findings help to develop a design guideline on the lighting environment according to the specific needs of different tasks. [12]

**Tab. 1. Font sizes used in the paper**

| Paper's Parts | Font Size | Italic | Bold |
|---|---|---|---|
| Main text, References | 9 | - | - |
| Headings e.g., Abstract | 11 | - | √ |
| Sub-headings | 11 | - | √ |
| Authors' names | 13 | - | √ |
| Paper Title | 15 | - | √ |
| Tables and Figures Captions | 10 | - | √ |
| Footnotes, Authors' affiliations, Sub and Superscripts | 8 | - | - |

## 3. Methods

The current research is an interventional and laboratory research, and with the aim of determining the relationship between cognitive activities with LED lamp color temperature and personality traits, male students of Tarbiat Modares University in Tehran in 2019, 35 university students were studied in this study. took, the participants were in a similar situation in terms of age range (mean age 27.03). The inclusion criteria were the absence of eye disease such as eye fatigue, vision loss, blindness, and mental-psychological disorders. On the day before the test, people were emphasized to have enough sleep and rest, and also to avoid taking medicine, coffee and caffeinated substances. In addition, before the implementation of the main steps, in order to familiarize people with the way of conducting the test, and to clear possible ambiguities during the research, a trial test should be held. Items considered for cognitive error include selective attention, response error, and reaction speed. Figure 1 shows the flowchart of the steps.
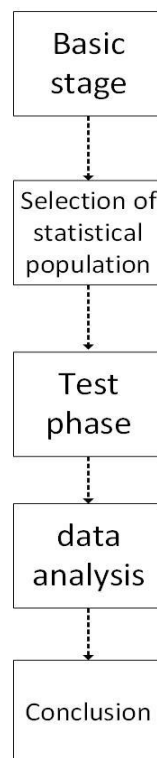


**Fig. 1. Flowchart of steps**

### 3.1. Data collection tools

The data collection tools in this study include a researcher-made questionnaire to collect

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demographic information, a Neo questionnaire to determine the personality characteristics of the studied subjects, and a Stroop test to examine cognitive activities. Stroop test is a practical method to check cognitive activities, the advantage of using this test is to check cognitive activities at the same time, which leads to reducing the test time. In this research, the following methods were used to collect information:

The NEO 5-factor questionnaire provides a comprehensive assessment of the main personality factors, the revised form of this tool is a self-assessment of personality characteristics that is based on a well-known personality model called the 5-factor model. Neo's five-factor questionnaire has 60 items that measure the five dimensions of normal personality. Each personality dimension in this questionnaire is examined and evaluated with 12 questions. The desired personality trait in this research is neuroticism (N), and questions number 1-6-11-16-21-26-31-36-41-46-51-56 are respectively related to this personality field. [13-14].

It should be noted that the Stroop test is a practical method for examining cognitive activities, the advantage of using this test is the simultaneous examination of cognitive activities, which leads to a reduction in test time. By using the Stroop test, problems related to students' fatigue and their lack of cooperation in the testing process can be reduced. The Neo questionnaire was also used in this experiment due to its high validity and reliability and the examination of personality traits separately. Also, during the studies conducted, this questionnaire has been confirmed in terms of culture and Persian translation. The methodology of this research is adapted from the study of Ruta Lasauskaite and colleagues [15]. The present research was conducted in two stages, before the implementation of the main stages, a test was conducted in order to familiarize people with how to conduct the test, and to clear possible ambiguities during the research.

## 3.2. Basic stage

Measurements and tests in this study were carried out in a fixed chamber. In the fixed chamber, the lighting system was replaced each time with lamps with different color temperatures (3000, 4000, 5000 degrees Kelvin) and the tests were performed. In order to design lighting in different colors, lamps with a power of 9 watts have been used in a specific color temperature (3000, 4000, 5000 degrees Kelvin), whose specifications are shown in table (1). To determine the accuracy and intensity of light, Hagner model EC1 lux meter was used, which was calibrated using the zero-point calibration method before each measurement. considering that the power and model of all three types of lamps used in the study were the same and the height of their placement was also the same, the intensity of their brightness was also the same and could not be except variable. Tests should be raised. However, the light intensity was measured with the mentioned device and its level was 250 lux in all three tests. In order to determine the effect of light color temperature on the selective attention, error rate and reaction speed of the participants, in the first stage, after collecting the demographic information of each person for 5 minutes in a room whose lighting was designed with a color temperature of 2400 Kelvin. It was placed to match the environment. After this period, in order to learn how to perform the Stroop test and to recognize the colors and the location of the keys, the examiner was asked to perform the Stroop test once completely under the lighting conditions of 2400 Kelvin (basic conditions). The results of this step did not affect the final results. And except for the data of the study, this step was done in order to get familiar with the Stroop test and perform it correctly.

**Tab. 2. Specification of bubble LED lamp - 9 watt**

| Power & Model | 60W 9A |
|---|---|
| Lm | 810-900 |
| Correlated Color Temperature | 5000(k)3000-4000- |
| CRI (Color Rendering Index) | <80 |
| Base | 27 E |
| Energy Grade | A + |
| Code Number | AFRA-B-0901 |
| Beam Angle | 230˚ |
| Current | mA 80 |
| Voltage | 200~240 V AC |

| | |
|---|---|
| SDCM (Standard Deviation Color Matching) | 6> |
| Life time | 25000 Hr |

### 3.3. Testing stage

The measurements and tests in this study were carried out in a fixed and completely dark room where no light source (artificial and natural) was involved. 5000 degrees Kelvin) was replaced and the tests were performed. That is, it can be said that only the lighting system used in the chamber was the lamps designed for testing.

After the implementation of the first stage, the room lighting system was replaced with a system with a color temperature of 3000, 4000, 5000 degrees Kelvin, and the subjects were studied again using the Stroop test after resting for 5 minutes and matching the desired color temperature. In order to avoid fatigue, the experimenter rested for 5 minutes between each stage of the test. The testing time for each person by the software was about 8 to 11 minutes, changing the color temperature of the lamp was not in a specific order, this was done in order to remove the matching factor on the overall results. After the end of the experiment, in order to check the personality characteristics of people, the Neo questionnaire was given to them.

The Stroop test is used in various researches in various clinical groups to measure response inhibition ability, selective attention, cognitive variability and cognitive flexibility. This test consists of two practice parts and the main test, each of which has 3 stages:

The first stage or preliminary stage is naming the color. In this stage, the subject was asked to respond by pressing the color of the circle he sees on the screen (the circle is shown in four colors, red, blue, yellow and green). The purpose of this stage was only to practice and recognize the colors and key positions on the keyboard, and it had no effect on the final result. With each correct or incorrect feedback response, the answer was presented on the screen.

The second step, which is naming the word, is an experimental step and is performed exactly according to the method explained in the main step (the next step), the purpose of this step is only to practice and familiarize yourself with the way of answering and the location of the keys on the keyboard. And it has no effect on the final result. At this stage, the names of the colors appear in a white box, and as soon as the word is seen, the examinee must press the color word corresponding to the word on the keyboard.

In the third stage, which is the main stage, consonant and dissonant words (red-green-blue) are shown randomly and sequentially on the monitor screen. The subject only emphasizes the color and without considering its meaning, the subject must choose the related color based on the label. Press on the keyboard. The tool used in this research was prepared by computer based on Delphi programming language. In the third stage or the main stage, 240 congruent and 240 incongruent colored words with red, blue, yellow and green colors (480 words in total) are shown to the subject in an overlapping and consecutive manner. The meaning of consonant words is that the color of the word is the same with the meaning of the word, for example, the word green is displayed with a green bell, and the meaning of dissonant words is that the color of the word is different from the meaning of the word, for example, the word red is displayed with the color of blue, green or yellow. Is shown. These 480 words are grouped into 20 sets and each set consists of 24 consonant and dissonant words. The difference between these sets is the duration of the interval between the two stimuli. These times include 550, 650, 750, 850 and 950 thousandths of a second, which are applied equally and randomly to each set.

Calculation of total error responses as well as calculation of response time (RT) for each person were considered in order to determine the amount of error and reaction time. The measurement of interference time and interference score, which are indicators of selective attention, were calculated by measuring the difference in error rate and reaction time in recognizing consonant and dissonant words, respectively. (The interference time is obtained from the difference in the duration of responding to the group of consonant words from the duration of responding to the group of incongruent words, and the interference score is also obtained in a similar way and from the difference in the number of error responses in the group of congruent and incongruent words.) After entering the information of each person in the section related to the examiner, by showing the

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screen to the examinee, it is said: it will be displayed on the computer screen in red, yellow, green and blue colors and you must click on the keys click. specified the correct color at specified speed.

After the implementation of this part, which was for the purpose of getting familiar with the test implementation method, the next part will be taught to the person. In this section, people are told, it will show you color words that should only be shown on the correct color. At this stage, the individual is told that color words may be presented that are the names of another color (eg, the word blue represented by red). The subject's task in this whole test is to

determine the correct color. Then the sample part of the test will be provided to the individual and the subject will be asked to follow the instructions.

When the subject fully understands, the examiner will tell the person (if you are ready to start) the test will begin when the person declares readiness. After performing the speed test, the person's reaction time in answering each word, the number of correct and incorrect answers, as well as other information related to answering, will be accurately calculated. Figure 2 shows the person of one of the test participants.
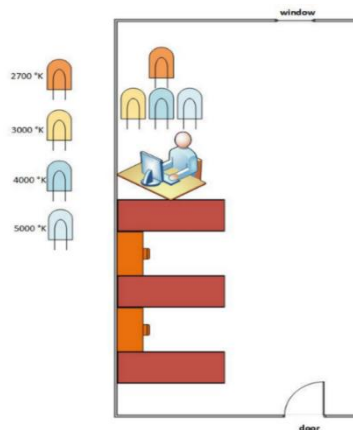


**Fig. 2. Test chamber and equipment for lamp temperature and color**

### 3.4. Data analysis method

The subjects studied in this research were selected randomly among the male students of Tarbiat Modares University. The number of samples was calculated according to previous similar researches and after performing statistical calculations and through Cochran's formula with a confidence factor of 95% (5% error), which was equal to 35 people.

$$n = \frac{Nz^2 \mathrm{pq}}{Nz^2 + z^2 pq}$$

Cochran's formula (n: number of samples, N: population size; z: equal to 1.96; p=q=0.5; d: permissible error value (error value).

Information collected from demographic questionnaires, Neo test and Stroop test using descriptive statistical methods (arranging tables, frequency distribution, determining central and dispersion indicators, drawing graphs) and also using analytical statistics methods (Pearson's correlation test) and in The confidence level of 95% of the data was analyzed using SPSS version

22 software [16, 17].

## 4. Ethical Considerations

This study was conducted with the aim of the effect of LED lamp color temperature and personality type on students' cognitive activities, and full explanations were given to the subjects.

## 5. Results

In general, 35 students with an average age of $27.03 \pm 2.20$ years participated in this study. All the participants were male and 33 of the participants (94.28%) were single and 34 of the studied subjects (97.14%) had a master's level of education and the rest were doctoral students.

Examining the number of correct answers in the group of consonant and dissonant words in three color temperatures of 3000-, 4000- and 5000-degrees Kelvin showed that the highest number of correct answers was in the group of consonant words and color temperature of 5000 degrees Kelvin (average 237.17). Also, the results showed that the lowest number of correct answers was in the group of dissonant words and at a temperature of 3000 degrees Kelvin with an average of 227.91.

Examining the number of error responses in three color temperatures of 3000, 4000 and 5000 degrees Kelvin shows that with the increase in color temperature, the number of error responses has decreased, the highest number of errors in the group of dissonant words and in the color temperature of 3000 degrees Kelvin with an average error of 10.8 and the lowest error rate with an average of 2.71 was in the group of consonant words and in the color temperature of 5000 degrees Kelvin (Table 2).

**Tab. 3. Number of correct answers in three color temperatures of 3000-, 4000- and 5000-degrees Kelvin**

| Variable | Description | Average | Standard deviation | minimal | maximum |
|---|---|---|---|---|---|
| 3000° K | Number of correct answers in consonant words (one unit) | 233.97 | 10.90 | 239 | 233.97 |
| | Number of correct answers in dissonant words (one unit) | 227.91 | 16.23 | 238 | 227.91 |
| 4000° K | Number of correct answers in consonant words (one unit) | 236.05 | 5.18 | 240 | 236.05 |
| | Number of correct answers in dissonant words (one unit) | 231.91 | 7.25 | 239 | 231.91 |
| 5000° K | Number of correct answers in consonant words (one unit) | 237.17 | 4.56 | 240 | 237.17 |
| | Number of correct answers in dissonant words (one unit) | 232.25 | 8.37 | 239 | 232.25 |
| 3000° K | Number of errors in consonant words (one unit) | 5.54 | 9.88 | 58 | 5.54 |
| | Number of errors in dissonant words (one unit) | 10.8 | 12.91 | 75 | 10.8 |
| 4000° K | Number of errors in consonant words (one unit) | 3.62 | 5.03 | 28 | 3.62 |
| | Number of errors in dissonant words (one unit) | 7.14 | 6.40 | 33 | 7.14 |
| 5000° K | Number of errors in consonant words (one unit) | 2.71 | 4.47 | 25 | 2.71 |
| | Number of errors in dissonant words (one unit) | 7.28 | 7.49 | 37 | 7.28 |

Examining the response time in three different color temperatures showed that with the increase in color temperature, the time to respond to the Stroop test decreased. So that the lowest value with an average of 601.22 milliseconds at a color temperature of 4000 degrees Kelvin and in the group of consonant words and the highest response time in the group of dissonant words was at a color temperature of 3000 degrees Kelvin with an average of 645.88 milliseconds (Table 4). Also,

the results show that Interference Time, which is one of the defining parameters of selective attention, and the difference in response time to groups of consonant and dissonant words

Interference Time = Response Time (dissonant) - Response Time (consonant)

It has been associated with a decrease with the increase in color temperature, the low interference time is effective in increasing selective attention. (Table 3)

**Tab. 4. Investigation of response time and interference time in three color temperatures of 3000-, 4000- and 5000-degrees Kelvin**

| Variable | Description | Average | Standard deviation | minimal | maximum |
|---|---|---|---|---|---|
| 3000° K | Response time for consonant words (ms) | 616.22 | 51.34 | 734 | 616.22 |
| | Response time for dissonant words (ms) | 645.88 | 64.37 | 803 | 645.88 |
| | Interference time (ms) | 29.65 | 21.29 | 4 | 92 |
| 4000° K | Response time for consonant words (ms) | 601.22 | 41.50 | 732 | 601.22 |
| | Response time for dissonant words (ms) | 628.45 | 55.07 | 814 | 628.45 |
| | Interference time (ms) | 27.22 | 18.38 | 0 | 82 |
| 5000° K | Number of correct answers in Response time for consonant words (ms) | 616.94 | 49.44 | 768 | 616.94 |
| | Response time for dissonant words (ms) | 644.68 | 57.20 | 814 | 644.68 |
| | Interference time (ms) | 27.74 | 15.89 | 7 | 67 |

Interference score: Examining the results related to the interference score, which is a parameter indicating selective attention, shows that with the increase in color temperature, the interference score has decreased, and this decrease indicates the increase of selective attention in the high color temperature of the LED lamp. The interference score is also obtained by the same method as the interference time and from the difference in the number of wrong answers in the group of consonant and dissonant words:
interference score = Error Number (incongruent) - Error Number (congruent) (Table4)

**Tab. 5. Checking the interference score in three color temperatures of 3000-, 4000- and 5000-degrees Kelvin**

| Variable | Description | Average | Standard deviation | minimal | maximum |
|---|---|---|---|---|---|
| 3000° K | interference score (one unit) | 6.05 | 6.46 | 0 | 32 |
| 4000° K | interference score (one unit) | 4.14 | 6.62 | 0 | 15 |
| 5000° K | interference score (one unit) | 4.91 | 4.50 | 0 | 21 |

The results showed that at a temperature of 3000 degrees Kelvin, there was a negative and significant correlation between the personality type of the investigated subjects and the interference score (parameter specifying selective attention) (P value<0.05) (Table 5)

**Tab. 6. The relationship between cognitive activities and the personality type of the studied subjects at a color temperature of 3000 Kelvin**

| Variable | Pearson correlation (r) | P value |
|---|---|---|
| Interference time (ms) | - 0.157 | 0.367 |
| interference score (one unit) | - 0.361 | 0.033 * |
| number of errors (one unit) | - 0.271 | 0.115 |
| whole number (one unit) | 0.259 | 0.132 |
| no answer (one unit) | 0.259 | 0.269 |
| Response time (ms) | Consonant   - 0.189 | 0.276 |
| | Discordant   - 0.202 | 0.242 |
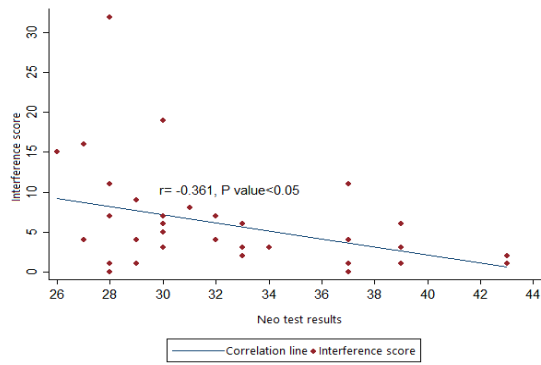
**Fig. 3. The relationship between the interference score and the personality type of the studied subjects at a color temperature of 3000 Kelvin**

**Determining the relationship between selective attention, error rate and reaction time in the face of LED lamp with color temperature of 4000 Kelvin with personality type**
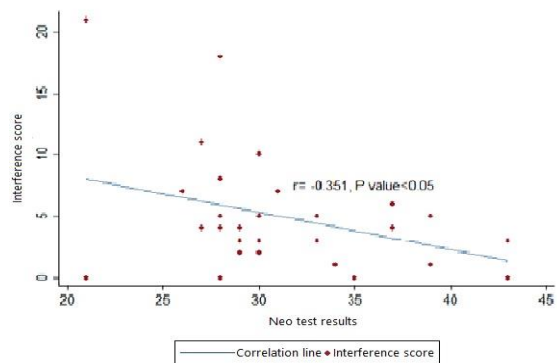
The relationship between the personality type and the cognitive activities of the students at the temperature of 4000 degrees Kelvin showed that there was no significant relationship between the personality type of the people with the interference score of the people, the number of wrong answers in the two groups of consonant and non-consonant words and the reaction speed (P value) >0.05.

**Determining the relationship between selective attention, error rate and reaction time when faced with a LED lamp with a color temperature of 5000 Kelvin with personality type**

In examining the relationship between cognitive activities and the personality type of people in the face of the LED lamp with a color temperature of 5000 degrees Kelvin, the results showed that the personality type of the people had a significant negative correlation with the interference score and the interference time (P value<0.05). (Table6)

**Tab. 7. The relationship between cognitive activities and the personality type of the studied subjects at a color temperature of 5000 Kelvin**

| Variable | Pearson correlation (r) | P value |
|---|---|---|
| Interference time (ms) | - 0.106 | 0.042 * |
| interference score (one unit) | - 0.351 | 0.038 * |
| number of errors (one unit) | - 0.323 | 0.057 |
| whole number (one unit) | 0.308 | 0.071 |
| no answer (one unit) | - 0.112 | 0.520 |
| Response time (ms) | Consonant   - 0.189 | 0.276 |
| | Discordant   - 0.202 | 0.242 |



**Fig. 4. The relationship between the interference score and the personality type of the studied subjects at a color temperature of 5000 Kelvin**

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**Determining the relationship between cognitive activities when exposed to LED lamps with different color temperatures in the studied subjects**

The results of people's cognitive activities when exposed to three color temperatures of 3000-, 4000-, and 5000-degrees Kelvin showed that with the increase in color temperature, people's cognitive activities improved (reducing the number of errors, reducing reaction time, and increasing selective attention), but this difference from Statistical opinion was not significant in three color temperatures. (P value<0.05)

The lowest number of error responses in the group of consonant words and in the color temperature of 5000 degrees Kelvin with an average of 10, the lowest reaction time in the group of consonant words and in the color temperature of 4000 degrees Kelvin with an average of 602.22 and also the lowest interference score in the color temperature of 4000 degrees Kelvin with an average of 4.14 was observed.

**Tab. 8. Correlation between cognitive activities and the color temperature of LED lamps in the studied subjects**

| Variable | color temperature | Average | Standard deviation | Min-Max | Statistics F | P value* |
|---|---|---|---|---|---|---|
| Interference time (ms) | 3000° K | 29.6 | 29.21 | 4-92 | | |
| | 4000° K | 27.22 | 18.38 | 0-8 | 0.16 | 0.848 |
| | 5000° K | 27.74 | 15.89 | 7-67 | | |
| interference score (one unit) | 3000° K | 6.05 | 6.46 | 0-32 | | |
| | 4000° K | 4.14 | 6.62 | 0-15 | 1.30 | 0.278 |
| | 5000° K | 4.91 | 4.50 | 0-21 | | |
| number of errors (one unit) | 3000° K | 16.34 | 22.49 | 4-133 | | |
| | 4000° K | 10.77 | 11.08 | 1-61 | 1.64 | 0.198 |
| | 5000° K | 10.0 | 11.65 | 2-62 | | |
| whole number (one unit) | 3000° K | 461.88 | 26.88 | 320-476 | | |
| | 4000° K | 467.97 | 12.08 | 417-479 | 1.63 | 0.200 |
| | 5000° K | 469.42 | 12.71 | 412-478 | | |
| correct number (one unit) | 3000° K | 1.77 | 4.58 | 0-27 | | |
| | 4000° K | 1.25 | 2.34 | 0-9 | 34.1 | 0.265 |
| | 5000° K | 0.571 | 1.33 | 0-6 | | |
| no answer (one unit) | 3000° K | 6161.22 | 51.34 | 555-734 | | |
| | 4000° K | 601.22 | 41.50 | 543-732 | 1.22 | 0.301 |
| | 5000° K | 616.94 | 49.44 | 545-768 | | |
| Response time in consonant words (ms) | 3000° K | 645.88 | 64.37 | 577-803 | | |
| | 4000° K | 628.45 | 55.07 | 565-814 | 0.95 | 0.389 |
| | 5000° K | 644.68 | 57.20 | 565-814 | | |

❋**ANOVA**

## 6. Discussion

Appropriate lighting design is one of the most important factors affecting people's productivity and efficiency, and if the quantitative and qualitative lighting parameters are not taken into account in the lighting design of places and passages, it is possible that in addition to physical and mental effects (such as eye fatigue, vision loss, etc.) eye diseases), can also be effective in the occurrence of accidents. In many studies, quantitative parameters related to lighting, such as brightness level and brightness level, have been studied, but what remains hidden from the eyes of researchers are the qualitative parameters of light, such as light color and light color temperature. In this study,

which was conducted on the male students of Tarbiat Modares University, the effect of light color temperature on the parameters affecting the occurrence of accidents, such as error rate, reaction time, selective attention, and personality characteristics of people were studied. In the human-machine perception process, cognitive activities such as reaction time and attention in order to understand and analyze the conditions of the assigned task are structural elements.[18]

In many studies, quantitative parameters related to lighting, such as brightness level and brightness level, have been studied, but what remains hidden from the eyes of researchers are the qualitative parameters of light, such as light

color and light color temperature. In this study, which was conducted on the male students of Tarbiat Modares University, the effect of light color temperature on the parameters affecting the error rate, reaction time, selective attention and also the personality characteristics of the people was studied. In the human-machine perception process, cognitive activities such as reaction time and attention in order to understand and analyze the conditions of the assigned task are structural elements. [2].

In this study, in terms of cognitive activities, the average number of errors in the group of consonant words was the highest when faced with LED lighting with a color temperature of 3000 degrees Kelvin, and it was the lowest at a color temperature of 5000 degrees Kelvin. In the section on the number of errors in the dissonant words group, the average number of errors was the lowest at the color temperature of 4000 degrees Kelvin, and the highest number of errors in the dissonant words was observed at the color temperature of 3000 degrees Kelvin. In general, in two groups of consonant and dissonant words, the average number of errors in three color temperatures of 3000-, 4000-, and 5000-degrees Kelvin was 16.34, 10.77, and 10, respectively, which indicated a decrease in the number of errors at high temperature. In the study by Hoffman et al., the results showed that the level of activity-arousal and concentration is higher at the color temperature of K 6500 compared to K 4000[21]. In the present study, the number of correct cases in the total number of consonant and dissonant words was the highest at the color temperature of 5000 degrees Kelvin with an average of 469.42. Also, at the color temperature of 4000 Kelvin, the average correct answer in the total of consonant and dissonant words was 467.97. In the present study, at a higher color temperature, the number of correct cases increased as the number of errors decreased, although the relationship between the number of error responses, correct responses, and no responses according to the color temperature encountered was not statistically significant.

In addition to examining the reaction speed and the number of errors of the participants in the experiment, their selective attention was also examined according to the interference score obtained in three different color temperatures. According to the results, with the increase in color temperature, the amount of selective attention of the volunteers increased, so that the

average interference score of people at color temperature of 3000-, 4000-, and 5000-degrees Kelvin was 6.05, 4.14, and 4.91, respectively, which indicates a decrease in attention. There is a choice in the temperature of 3000 and 5000. The results of Huang et al.'s study, which was conducted with the aim of investigating the effect of color temperature on focused and sustained attention under LED light, showed that concentration and attention increase at a color temperature of 4300 degrees Kelvin [16]. In Farrokh Nejad's study, the results showed that unfavorable lighting and excessive use of artificial light during daylight hours cause visual fatigue and reduced accuracy, which confirms the results of our study. In order to reduce these effects in lighting design, it was recommended to use lighting close to daylight (high temperature) [17].

In the current study, in addition to investigating cognitive activities in different color temperatures, the relationship between cognitive activities and the personality type of people in different color temperatures was also investigated. And there is a significance (P value = 0.033). Also, at the color temperature of 5000 degrees Kelvin, a negative and significant correlation was observed between the interference score (P value = 0.038) and the interference time (P value = 0.042) of the students. The attention index is one of the most important indices used in examining the mental and psychological performance of people to show their cognitive status. These results show that increasing neuroticism characteristics in people at 3000- and 5000-degrees color temperature can cause a significant decrease in selective attention.

In a study by Babaei et al., which was conducted with the aim of investigating the relationship between the 5 main elements of personality and the number of medical errors among nurses and doctors, the results showed that people with personality traits of extroversion, conscientiousness and openness to experience significantly have errors. are less, also people with neurotic trait had a significantly higher number of errors [3].

Based on the studies conducted in the field of lighting and its effects on people's cognitive activities and physiological response, it has been determined that the color temperature and intensity of the light create different responses in people, for example, most people increase the level of consciousness by increasing the color temperature of the light. and show more

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mental activity, on the other hand, some studies have shown that the feeling of satisfaction and then the level of accuracy in facing low temperature or warm light is higher, since these factors in different studies, different results on the performance and efficiency of people, achieving a high efficiency by applying changes in the quantity and quality of lighting requires more studies and investigations.

The results of this study showed that the LED lighting system with a color temperature of 4000 can be effective on people's cognitive performance by reducing errors, reducing reaction time and increasing attention. Also, according to the results obtained in relation to the relationship between personality type and cognitive activities of people, it was found that with the increase of neurotic characteristics, the amount of attention decreases significantly in the color temperature of 3000 and 5000, according to these results and in order to promote The performance of people in the systems is recommended to use LED lighting system with a color temperature of 4000 in sensitive places, and even people with a non-neurotic personality type had a better working condition in this color temperature than the color temperature of 3000 and 5000.

## 7. Conclusions

The results of this study showed that in terms of cognitive activities, the average response time of the volunteers when facing the LED lamp with a color temperature of 4000 degrees Kelvin was the lowest (the average time was 601.22 milliseconds in the group of consonant words and the average time was 628.45 milliseconds in the group of words incongruent), and the highest reaction time of the candidates was at the color temperature of 3000 degrees Kelvin with an average of 645.88 milliseconds in the group of incongruent words and 616.22 milliseconds in the group of congruent words. At the color temperature of 5000 degrees Kelvin, the average reaction time of the subjects was compared With the color temperature of 3000 Kelvin, there was little change and in general it decreased slightly (average of 616.94 milliseconds in the group of consonant words and 644.68 milliseconds in the group of dissonant words). Although statistically, no significant difference was observed between the reaction time at the color temperature of 3000, 4000 and 5000 degrees Kelvin. The results of previous studies in this case are not consistent. The results of Yingwei Zhou's study showed that color temperature has no significant effect on reaction time [22]. which

confirmed the results of our study, but the results of Ferlazzo et al.'s study showed that the use of LED lighting with a color temperature of 4000 Kelvin improves reaction time and cooler colors improve cognitive capacity and performance [23].

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