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The Effect of the Colours on the Perception of Time among Players of Computer Games: A Narrative Review

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Review Article

Abstract

Introduction: Colors are among the effective factors in human life, which are related to human feelings and emotions more closely than other visual elements. The perception of time may vary in different physical environments according to the colors. The aim of this study is to review the studies on the effects of colors on the perception of time in computer games.

Materials and Methods: Data were collected through library research in Civilca, Noormags, Scientific Information Database (SID), and Scopus databases; Google Scholar and Science Direct search engines were also used. The search keywords included: color, color psychology, time, and time perception. English and Persian articles since 2000 (1380 Persian Calendar) were included.

Results: Among 65 articles found regarding colors and psychology of colors as well as the perception of time and color impact on the perception of time, 28 articles, which were related most, were selected. Based on the search, it seems that the plan had not been investigated in the context of the computer games. According to the studies in the field of architecture on some colors (blue and red), these colors may also be used in computer games. With the combination of these colors, perfect time perception may be provided for game players

Conclusion: The time perception and the impact of color on it was often investigated in architectural studies and interior or urban decoration while no study was found specifically in the field of computer games. Although those studies may be considered as the basis for implementing color compositions in computer game graphics, scientific studies basically in the field of computer games are essential for detailed analysis.

Keywords: Color; Color psychology; Time; Perception of time; Computer games

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Introduction

Part of an individual's experience of the environment and the world around him is achieved through perceptions of different color spectrums; a world that is composed of many and varied elements and manifests itself in a different way under the influence of colors which may seem more attractive or boring than they are (1). Psychology is a science that deals with the mind or spiritual dimension and emotional processes and specific references to behavior, and provides an understanding that behavior includes thought, feeling, and every dream of one's experiences, the roots of which are conscious, semi-conscious, and unconscious processes (2). The conscious experience indicates that we are aware of what we think and feel, the semi-conscious experience refers to those mental processes that are perceived unconsciously or slowly, and finally, the unconscious experiences are the whole thoughts, memories, sensory impulses (motivations), desires, interests, and feelings that we are not aware of (2). Emotions and colors are also part of the conscious, semi-conscious, and unconscious experiences that are embedded in human behaviors and affect them (3). The subject of color and its effects is very complex and is therefore discussed in

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part of the psychological topics (2). This field of psychology addresses issues of color awareness and attitude towards it as an element of visual experience (4).

According to Ernst Poppel, time is not an empirical concept, but a vital idea that is the basis of all human perception (5). The issue of time perception in the field of neuroscience is also one of the most controversial issues. The individuals' perceptions of elapsed time are often different, depending on their mental or emotional states (6). The effect of color on human perception of space and time has been one of the areas of research by psychologists (6-9). Each person has a specific time perception and sense of each color given their individual and cultural characteristics. Due to these characteristics, some people have a longer time perception of one color compared to another; while this may not be the case in another person (7).

Today, the computer game industry is very popular and few individuals are not familiar with this industry. Due to the increasing demand from consumers, computer game developers are using all their power to create the best games. Undoubtedly, one of the best ways to attract players' attention is to provide effective graphics. The graphics of the games should be such that it does not diminish the player's interest in the game. In the meantime, color can be one of the factors attracting the player's interest in the game. Depending on the time perception and sense of different colors for a person according to his individual characteristics, the type of color used in the game can make the passage of time for the player long or short. On the one hand, this can help game developers in the proper design of game graphics to reduce the boredom of players and their time perception, and thus, help to attract game users. On the other hand, in the analysis of addiction to computer and online games and from a psychological point of view, it can be valuable to help reduce the time of use of these games in children, adolescents, and young people. In addition, with the entry of computer games into the field of treatment, education, and rehabilitation, this tool can be used to gain more satisfaction of the specific clients of these goals, increase the efficiency of the game in the context of its designed goal, and increase motivation and follow the specific clients of these games. Accordingly, the present study is conducted with the objective to investigate the effect of colors in a computer game on the users' time perception.

Materials and Methods

Data were collected in the form of research and library studies. The articles used in this study included Persian and English articles collected from Civilica (conference and scientific-research articles), Noormags (scientific-research articles), and Scientific Information Database (SID) Persian databases and English articles from the Scopus database. The Google Scholar and Science Direct search engines were also used. Articles conducted in the fields of color and color psychology, as well as the psychological effect of colors on different individuals, time, the time perception of individuals, and how individuals perceive time and the effect of color on it, were selected. Moreover, articles that discussed these issues in different age and gender groups were included in this study. The keywords searched for to find the related articles included Color, Psychology of Color, Time, and Temporal Perception or Perception of Time, and the main objective was to collect studies published in the last 20 years since 2000 (1380 Persian Calendar) onwards. If the full text of the articles was not available, the first author, the corresponding author, or the journal editor was contacted to receive the full text of the article.

Results

First, searching for the keywords, more than 100 articles were obtained, some of which were discarded because they were old in terms of the year of publication and had little to do with the topic. Then, out of the remaining 65 articles, 27 articles were selected and reviewed. The selected articles were new and up-to-date in terms of the year of publication and included the most relevant topics thematically. The text of all articles was available. Table 1 lists some of the selected articles.

Discussion

In the present narrative review study, studies dealing with color, time perception, and the effects of colors on time perception were collected and reviewed. Most of the studies on the effect of color on the time perception were in the field of architecture or interior or urban decoration. The results suggested that some colors (including red) make people perceive time longer, and in contrast, some other colors (including blue) shorten the perception of time. No study was found in this area that directly examined the perception of time in computer game users. Before reviewing and analyzing the collected texts, it was necessary to define the basic concepts used in this review to gain a unified understanding of the issues raised in the articles.

Basic Concepts

Color The most accurate scientific definition of color is in Webster's dictionary; Color is a characteristic of an object, described as the theme, brightness, and saturation, and is associated with the visible wavelength that stimulates the eye organs (16).

Table 1. Summary of the studies reviewed

Reference	Main topic	Indicators studied	Results
Mousa Pournegary and Hassan Poor (1)	Investigation of color role in architecture design and its impact on human and environment	Color, color psychology, the effect of colors on humans, the use of colors in architecture	As an important visual factor, color can be stressful or soothing. With optimal interior design, calm and freshness can be achieved in the environment with proper use of colors. Color as a property, depending on the objects around us, has relative properties and effects on different individuals and in different environmental conditions, but the general and basic properties of colors can still be used purposefully to improve the quality of life (QOL) and increase human efficiency in the work and life environment.
Khorsand et al. (4)	Evaluation of the psychological impact of color in the quality of interior perception	Color, psychology, effect of color, quality of perception	There is a continuous relationship between the environment color and our feelings and perception of it. It can be seen that some colors are described as very active, some as ordinary, and some as soothing. All studies show that color cannot be considered as a neutral element of the environment. Color is a complex subject that is influenced by factors such as the lighting conditions, individual tastes, and perceptions of color proportions, and the object painted is as important as the concept of a color. It should be noted that the perceptual effects of color affect the performance of users in its environment.
Ghadarjani et al. (10)	Evaluation of color impact in interior architecture of educational spaces	Color, color psychology, interior architecture	Choosing the right color to cover the classrooms is the first step in color design for the decoration of each classroom. Architects should pay more attention to the educational space and design it according to their needs. This study helps architects to design the educational spaces according to the needs of students.
Movaghar and Ariyafar (11)	Studying the impact of paint in interior design of buildings	Color, interior design, color psychology, color combination	Color is one of the most important elements by which a designer can convey a mental message. As much as the color attracts the user's attention, it can also pose challenges for the designer. Knowing the type of colors and knowing how color relationships can save the designer time and energy. Therefore, the designer can make a correct design and provoke the right reaction in the user taking into account the definition of color and the correct methods of choosing colors and combining them with each other, as well as the correct psychology of colors.
Yousefi Akbar (12)	Investigation of the psychological impact of color on human perception from architecture of residential spaces	Effect of color, psychology, architecture, residential spaces, human perception	Color in different situations has different effects on architecture. One of the most important of these effects is on mental health. The role of color in the design of architectural spaces is so essential that it should be considered as an important factor during the design process and not after its completion. Based on the use of spaces, considering this element as the main design element, they can be animated and in other words, the uses can be specified. Color is so important in architecture that people, whether aware of it or not, will be impressed by it.
Nazari et al. (8)	The role of working memory in the process of transformational time perception in school-age children	Time perception, time reproduction, primary school children	The aim of this study was to investigate the role of working memory on the evolution of time perception in primary school children. The findings indicated that the effect of growth length on time perception was statistically significant in long-term single task and in long-term dual task. In other words, it can be said that with age, children's perception of time in single and dual long-term tasks improves.
Alipour et al. (13)	A study of the effect of handedness, sex and age on the time perception	Time perception, age, gender	Although right-handed people have a higher estimate of time than left-handed people, but in recognizing the difference between two times close to each other, they make significantly more mistakes. Additionally, the older people get, the faster they perceive the passage of time.
Lashani and Shaeiri (14)	Physics and psychology time perception: parallelism or contrast	Psychology, energy and time	The findings of psychology and physics in a consistent way with each other show the effect of energy on time. Accordingly, it seems that an increase in energy in humans can lead to a slower perception, and a lack of it can lead to a faster perception of time.

Table 1. Summary of the studies reviewed (continue)

Reference	Main topic	Indicators studied	Results
Shibasaki and Masataka (9)	The color red distorts time perception for men, but not for women	Color, Time Perception, Gender	A screen with two colors blue and red (each of the colors was displayed on the screen with the same duration, for example 30 seconds blue and 30 seconds red) was shown to both genders and it was concluded that the subjects perceived the red screen longer than the blue screen; Of course, this perception was different for the men and women, and the men perceived red time longer than women.
Grondin (15)	Video games and the perception of very long duration by adolescents,	Time perception, Video games, Attention	In this study, the participants spent 24 minutes playing a computer game and 8 minutes reading a text on a monitor. The results revealed that the subjects perceived 24 minutes less than this time and the passage of the game for them was less than the intended time, and on the contrary, the passage of another time was more than the original duration for them and they perceived the time of 8 minutes longer.

Some define color as the visible reflection of the passage or propagation or reflection of beams of a certain wavelength in the visual range (2), which refers to the physical and chemical dimensions of color, rather than its nature. In Dehkhoda Dictionary, color is a light effect that gives different representations to the appearance of objects; this means that the special effect that takes place in the eyes due to the reflection of light beams on objects is defined as color (17).

Psychology of color and the effect of color on humans: The psychology of colors is one of the important aspects in the study of colors. Paying attention to colors as the aesthetic elements of the human environment is of special importance. It can be said that colors are very effective in the human psyche (4). People tend to like certain colors. Using this tendency of individuals as a means of identifying their personality is a controversial issue (18). Colors affect the human psyche to such an extent that they cause behavioral changes, and this type of change leads to changes in the characteristics and personality of individuals (2). Colors can have a fundamental impact on life in a variety of ways, the most important of which is their effect on emotions (18). Colors have always been a means of expressing feelings and ideas (2) and are closer to human feelings and emotions than all other visual elements (19). The effect of color on the psyche and mental states is through its stimulating effects on sensory receptors and the processing of these stimuli in the brain (20). Each color has a special meaning and reflects the feeling with a special physical and mental effect it has on the viewer, and people show different reactions in this regard. Le Corbusier believes that color comes back to us and that each of us may have our own color (2). The world in which man lives consists of thousands of different colors and tonalities that make beings and objects more attractive to us and even more spiritually profound (19).

The effect of color on the human mind and psyche is a proven and evident matter (4,12,20). In their living environment, human beings consciously or unconsciously interact with colors and are influenced by them. These effects can occur physiologically (4). Colors have become symbols of inner feelings and personality and social states over time (21). Psychologists have studied the effect of colors on individuals and described their moods (1,4,5,22). Each color, due to its properties, affects the psyche of individuals in a way that this effect is related to the social and psychological behaviors of the individuals (1). Visual, electromagnetic, and chemical processes in the eyes and brain are always associated with the processes of the world of psychology. Such reflections of the color experience may penetrate the innermost centers and thus affect sensory and intellectual cognitions (1). Due to its chemical and psychological properties, each color is an important source of energy in order to promote the health and vitality of the soul and spirit in humans (19). Colors create different sensations in people, and if this issue is not considered in choosing colors, it will cause anxiety and confusion (22). Individuals' reactions depend on several factors such as culture, gender, age, emotional and mental status, and specific individual experiences; however, the type and severity of these reactions are unique (18).

Time: Time and place are the two main dimensions of life (23). Although in today's computerized world, space has gradually lost its value and importance, time has become more important. Time is the basis of daily activities and includes the sleep-wake cycle to walking, talking, playing, playing music, exercising, etc. (24). We participate in these activities and use and process time information over a wide range of intervals. Although there are no specific sensory receptors or organs in relation to time perception, temporal information processing is an

important part of daily life (25). Attention to the passage of time causes the length of time to be considered longer and attention deviation leads to a shorter estimate of the length of time (24).

Perception of time: Despite the pervasive presence of time in the experimental world, the sense of time is a special feeling (26). Time perception is an adaptive functional that provides the ability to predict and respond appropriately to upcoming and future events (25). The ability to perceive and represent time is a fundamental and complex cognitive skill that allows a chain of events and activities to be perceived and the occurrence of some future events to be predicted (26). Intangibility, the lack of a specific sensory organ for the perception of time, and the incompatibility of the perceived time with physical time have led to many factors, such as attention, memory, arousal, and emotional states, as well as pleasure and in general, mental state all are considered as potential modifiers of time perception (5,6).

Perception of time is a purely mental phenomenon. Depending on the circumstances, a situation can be perceived very quickly or very slowly (13). In general, it can be declared that positive emotions make time seem shorter; while negative emotions make time seem longer. This is abundantly found in our individual experiences (6). Slower perception of time means that an individual's perception of time is longer than its amount based on the clock. For example, if a certain time is indicated by a clock as 5 seconds and the person perceives that time as one minute, it indicates that the time is slow for him. Conversely, a faster perception of time means that the individual's perception of time is less than its clock value. For example, if a certain time is one hour based on the clock and the person estimates that time as 10 minutes, it indicates that the time is faster for him (14). In a study, participants were asked to play a computer game for 24 minutes at a time. Another time, these subjects read a text on a monitor for 8 minutes, and in both cases, they were unaware of the real time of doing these tasks. They were asked to guess the time of each of these two activities and they estimated the playing time less than its real duration and the study time more than its real duration (5).

Time perception tests: Time assessment tests are often of four types: "Time Estimation, Time Production, Time Reproduction, and Time Differentiation". To perform the above tests, the assigned tasks can be performed as single or dual. The main goal of the test in the individual tasks is to determine the duration of time. In other words, the subject does only one task, and that is to evaluate the duration of time. In dual tasks, the subject must simultaneously evaluate the duration of time while performing a cognitive task (8).

In estimating time, the time is presented verbally and the subject is asked to estimate its duration verbally using units of time such as seconds and minutes (15). In the production method, the tester specifies a duration and the subject is supposed to produce that time interval. In this method, there are two buttons to start and end the time intervals, or the subject has to press a button that is equal to the time interval (13). In the reproduction method, the tester presents a time interval with the continuation of an audio or visual stimulus and asks the subject to show the stimulus presentation time interval by an action (15). The fourth method, called the comparative method, is similar to the method used in psychophysical experiments. Participants in the experiment must judge which of the audio or visual stimuli presented in a row is shorter or longer and determine this by pushing a button. The participants are often faced with a two-choice condition. The psychophysical experiments are first performed at standard intervals and then compared, and this method is known as the reminder method (13).

Review of studies

Various studies have been carried out on color and time perception (9-7,13,27). Moreover, the effect of some colors on the time perception of individuals has been studied in several articles (7,9,13), which were mostly in the field of architecture (4,19,22) and urban places (10,28,29). However, based on the research performed in the present study, it seems that this issue has not been investigated in the field of computer games; however, due to the importance of computer games and their increasing desirability and use, there is a need for more efforts in this area. The game should not be boring for the player, and one of the primary solutions to this challenge is to change the player's perception of the game time. Observing aesthetic-based techniques in computer games to increase popularity among users and attract more audience, is a necessity, and therefore, graphics in this type of games have a special place. Among the factors that make the graphics of the games more beautiful, colors play the pivotal role.

Due to the lack of retrieval of articles that had purposefully examined the use of color in changing the time perception of computer game players, this section discusses studies that used colors in other fields to change the clients' time perception.

In color recognition architecture, basic knowledge about how it affects the interior decoration of the

building can increase the performance of human living spaces and ultimately, bring peace and satisfaction to users of everyday spaces (2,4,10,12,22,26). Shibasaki and Masataka conducted a study on men and women to find out which of the two colors red and blue the participants perceive longer of. Both genders were shown screens in two colors, blue and red (each color was displayed on the screen with the same duration. For example, 30 seconds of blue and 30 seconds of red). They concluded that the subjects perceived the red screen longer than the blue screen; Of course, this perception was different for men and women, and the men perceived the presentation time of the red color longer compared to the women (9).

In another study, the internal clock model was used, according to which part of the brain acts as a maker of time steps and part as a counter of these steps, and part is responsible for storing this time in memory. The delta and beta waves seemed to play a role in the overestimation and underestimation of individuals. However, the role of these waves in the perception of long time intervals has not been studied (6). The time scale varies in spaces of different colors. For example, listeners to a speech in a blue hall find it long and dull; while the same speech in a red hall is considered exciting and shorter (29). However, in another study it was observed that light and red space lead to overestimation of time and green or blue leads to underestimation of time in a person (27). Accordingly, the use of color combinations, by reducing a person's perception of time spent in the game, may be able to increase the time of use of serious games designed for education or treatment and rehabilitation, or in entertainment games aimed at preventing addiction, it may lead to a feeling of boredom after a reasonable time and prevent the player from continuing the game. As mentioned, scientific investigation in this field requires careful research in the field of serious computer games and entertainment.

Limitations

The most important limitation of the present study was the lack of access to studies that had specifically identified the effect of color on the perception of time in playing computer games. What was addressed in the present study was mainly based on the articles on architecture, interior decoration, and urban decoration, and it was not possible to generalize the results definitively.

Recommendations

Conducting studies in which different graphic themes of a game are presented to the audience and their perception of time is evaluated, will be worthy in choosing the theme and graphics of the games in order to prevent boredom and attract more users. On the other hand, due to the time-consuming sessions of rehabilitation interventions as well as its long treatment duration, the information collected in the present study can help to better design rehabilitation wards and centers so that the client is less aware of the passage of time and feels less bored of implementation of different activities in these environments.

Conclusion

The perception of time and the effect of color on it has often been considered in architectural and interior or urban decoration studies, and no study was found in the field of computer games. Thus, it may be possible to recommend the use of colors and their combinations in the graphics of computer games, but for detailed analysis, scientific research in the field of computer games is needed.

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Authors' Contribution

Maryam Haghi: Study design and ideation, providing study equipment and samples, data collection, analysis and interpretation of results, manuscript preparation, specialized evaluation of the manuscript in terms of scientific concepts, approval of the final manuscript to be submitted to the journal office, the responsibility of maintaining the integrity of the study process from the beginning to the publication, and responding to the referees' comments; Behnam Alizadeh-Ashrafi: supportive, executive, and scientific study services, analysis and interpretation of results, manuscript preparation, specialized evaluation

of manuscript in terms of scientific concepts, approval of the final manuscript to be sent to the journal office, responsibility to maintain the integrity of the study process from the beginning to publishing, and responding to the referees' comments; Shiva Nasr-Esfahani: data collection, analysis and interpretation of results, manuscript preparation, specialized evaluation of manuscript in terms of scientific concepts, approval of the final manuscript to be sent to the journal office, responsibility to maintain the integrity of the study process from beginning to publication, and responding to the referees' comments.

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Conflict of Interest

The authors do not have a conflict of interest. Dr. Behnam Alizadeh-Ashrafi has been working as a faculty member at Tabriz Islamic Art University since 2014. Maryam Haghi has been a graduate student of Computer Arts majoring in Computer Game Production since 2018 and Shiva Nasr-Esfahani has been a graduate student of Computer Arts majoring in Smart Simulator at the School of Multimedia of Tabriz Islamic Art University since 2017.

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