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Цвет в образовательной среде для пожилых людей: обзор современных исследований

Цель статьи заключается в том, чтобы представить анализ существующих в отечественной и зарубежной науке исследований необходимой возрастной «корректировки» цвета образовательной среды для пожилых людей, выполненный с учетом того факта, что цветовая коммуникация не сводится исключительно к биологическим реакциям, а ее структура, кроме перцептивного, включает гораздо более значимые психологические механизмы и семиотические уровни.

Отбор источников исследования осуществлялся через системы РИНЦ, Google Scholar, Scopus, Web of Science. Всего было проанализировано 63 полных текста статей, опубликованных в период с 1999 по 2019 год. В процессе работы использовались методы теоретического и сравнительного анализа, систематизации и обобщения материала.

Проведенный анализ позволил выделить три группы исследований. Первая группа включает работы, в которых представлены физиологические предпосылки необходимых изменений цветового оформления образовательного пространства, предназначенного для пожилых людей. Вторая группа исследований анализирует различные аспекты воздействия цвета образовательной среды на пожилого человека в психологическом контексте. Третья группа – затрагивает социокультурные аспекты формирования образовательной среды для пожилых людей и анализирует этот феномен с точки зрения связи с образом жизни и мышления стареющего человека, его физической и эмоционально-интеллектуальной активностью, социально-бытовыми условиями.

Результаты исследования убеждают в том, что корректировка цвета в образовательной среде, предназначенной для пожилых людей, способна вызвать заметные изменения качества обучения сразу на нескольких уровнях – биологическом (повышая доступность информации и заметно снижая физиологические барьеры восприятия), психологическом (поддерживая и укрепляя процессы запоминания и обработки информации, повышая психологический комфорт образовательной среды) и социальном (повышая качество жизни пожилых людей).

Ключевые слова: цвет, образовательная среда, пожилые люди, обзор исследований

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Color in the educational environment for older people: recent research review

The purpose of the article is to present an analysis of the studies existing in domestic and foreign science of the necessary age-related "correction" of the color of the educational environment for older people, carried out in respect of the fact that chromatic communication is not limited exclusively to biological reactions, but its structure, in addition to perceptual one, includes much more significant psychological mechanisms and semiotic levels.

The selection of research sources was carried out through the RSCI, Google Scholar, Scopus, and Web of Science systems. In total, 63 full texts of articles published between 1999 and 2019 were analyzed. In the process of work, the methods of theoretical and comparative analysis, systematization and generalization of the material were used.

The analysis made it possible to distinguish three groups of research. The first group includes works that present the physiological prerequisites for the necessary changes in the chromatic design of the educational space intended for older people. The second group of studies analyzes various aspects of the impact of the color of the educational environment on older people in a psychological connotation. The third group involves the socio-cultural aspects of the formation of the educational environment for older people and analyzes this phenomenon in terms of connection with the lifestyle, way of thinking, physical and emotional-intellectual activity, and social conditions of the aging person.

The results of the study convince that color correction in an educational environment designed for older people can cause noticeable changes in the quality of learning at several levels at once – biological (increasing the availability of information and significantly reducing physiological barriers to perception), psychological (supporting and strengthening the processes of memorization and information processing, increasing the psychological comfort of the educational environment), and social (improving the quality of life of older people).

Keywords: color, educational environment, older people, research review

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Introduction

The revolutionary nature of the change in life expectancy causes a noticeable deformation of the modern demographic structure of the population and results in the formation of a special, previously nonexistent lifestyle, the signs of which are determined by the biological, psychological, and social characteristics of older people.

According to statistics, people of the "third age" are actively involved in the processes of continuous education throughout their life [14], which becomes for them not only a source of professional improvement but also an important condition for social adaptation [9], personal development [10], preservation of creative potential and active life position [17; 21]).

The world experience in teaching older people at institutions of various types (see, eg: [3; 83]) makes it possible to assert that this teaching area requires special didactic approaches, specific methods, educational proposals and technologies [15] and assumes "chromatic adaptation" [89, p. 91] of the educational infrastructure and educational environment to the conditions of the new "gerontological reality" (this refers to the color design of classrooms, reference literature, teaching materials, and even training and specialized computer programs).

The purpose of this article is to present an analysis of existing in domestic and foreign science studies of the necessary age "correction" of the color of the educational environment for older people, carried out in respect of the fact that color communication is not limited exclusively to biological reactions, but its structure, except perceptual, includes much more significant psychological mechanisms and semiotic levels.

At the same time, the educational environment is understood as a set of conditions that affect the development and formation of abilities, needs, interests, the consciousness of the individual [11], and includes educational technologies, material and technical equipment of educational institutions, educational and developmental literature as components (see, eg: [16; 20]).

Materials and methods

The selection of research sources was carried out in 3 stages using the RSCI, Google Scholar, Scopus, and Web of Science systems.

At the first stage, a database of scientific articles was formed that could potentially be related to the problem under study. The primary selection was carried out on the basis of the analysis of the titles and abstracts of sources for three groups of keywords:

- (1) *color, chromatic, hue, color vision, color perception, color cognition;*
- (2) *older people, elderly people, aged people, aged observers, older adults, aging), life span;*
- (3) *educational environment.*

On the basis of initial selection, 1,356 scientific articles were included in the research database.

At the second stage, the search was refined using a combination of keywords. The list for this stage included 228 studies that contained terms from at least two keyword groups as heading and abstract keywords.

At the next stage, based on the analysis of the full texts of the abstracts, the sources directly related to the problem under study were selected. These texts were studied and analyzed in full.

Since the methodology for studying the mechanisms of color vision has significantly advanced in recent decades, the review was limited to a 20-year period and almost all works published prior to 1999 were excluded.

The choice of research boundaries is also explained by the fact that at the turn of the century, there were dramatic changes in the technology of using color in education, associated with the widespread use of color printing and the improvement of the technical equipment of the educational process. Moreover, the restructuring of the education system [1; 3] took place, which radically transformed the paradigm of research and the use of color in educational practice.

In total, 63 full texts of articles published between 1999 and 2019 were analyzed.

In the process of work, the methods of theoretical and comparative analysis, systematization and generalization of the material were used.

It should be noted that the age boundaries of the social group, which are usually classified as older people, are blurred and do not coincide in the works presented herein. Significant changes in physical and cognitive functions [80], retirement age [74], boundaries of generally accepted age classifications [89; 90], and a number of others are usually used as criteria.

There are also differences in terminology. The terms "people of silver age" [1], "people of the third age" [9; 13; 21], "people of gerontogenesis" [25] are used in the analyzed sources in addition to the term "elderly people" to designate the age cohort under study. The period after 60 years is most often referred to as the "period of late maturity", "gerontogenesis" or "the aging period" (see, eg: [25]).

Results

The analysis of scientific sources on the issues under discussion from the point of view of the available empirical premise, comparison of topics, methods, and research methodology made it possible to distinguish three groups of research.

The first group of works can be conditionally called the pedagogical physiology of color, since they consider the physiological prerequisites for the necessary changes in the color design of the educational environment intended for older people and simulate the conditions of the pedagogical process that are optimal from a physiological point of view, taking into account the age characteristics of older people.

In discussing the studies of this group, the authors consider it important to determine what physiological changes in color vision can reduce the effectiveness of the educational process (section 1.1) and how this can be avoided (section 1.2).

The second group of research that contributes to the development of color content in an educational environment for older adults addresses various aspects of the effects of color on older people in a psychological connotation and discusses the use of color in enhancing cognitive processes.

The central concept of this group of research is color cognition, which is understood as a set of mental (cognitive) processes of sensation, perception, thinking, memory, attention, imagination, and speech that serve to convert the information; at the same time, cognition

is interpreted in the broadest sense of the word, starting from the retinal mechanisms of color discrimination and ending with the nature of social stereotypes [24].

This group of research is focused on the influence of color on all processes during which sensory data is transformed, entering the brain, and transformed in the form of mental representations of various types (images, propositions, frames, scripts, scenarios, etc.) to persist in the memory of a person, if necessary.

The largest number of publications in this group contains an analysis of the results of experimental studies of the effect of color on attention (section 2.1), memory (section 2.2), and emotions (section 2.3) of older people and is aimed at improving the ways to improve the performance of cognitive processes.

The third group of research, which can be conditionally called the pedagogical sociology of color, addresses the socio-cultural aspects of the formation of educational space for the elderly and analyzes this phenomenon from the point of view of the connection with the way of life and thinking of an aging person, his or her physical and emotional-intellectual activity, social conditions and relationship between generations.

In the works of this group, color is considered in the context of its role in the life of older people (section 3.1), and the focus is on the mechanisms of making color decisions (section 3.2) and the environment that affects a person's social activity (section 3.3).

Discussion

(1) Pedagogical physiology of color

(1.1) Physiological changes in color vision and color perception in old age

According to the research, there are noticeable changes with age in organs and tissues that are involved in color vision. The pupil decreases in size and loses elasticity, allowing less light to enter the eye [82]. The lens becomes denser [26; 50], blerier [82] and noticeably turns yellow [26; 44; 51]. As a result, some of the light waves that hit the cornea are absorbed, scattered, and reflected, without reaching the retina. The ability of the lens to transmit light decreases from 95% at the age of 30 to 75% at the age of 53 and 31% at the age of 75 [26], and the most noticeable changes occur after 70 years [26; 51].

The number of photoreceptors that are responsible for night vision and sensitivity to low light and low contrast is rapidly decreasing [69]. The sensitivity of photoreceptors to the perception of color waves of all lengths – short, medium, and long – decreases [54].

As a consequence of all these physiological changes, people of old and great age see the world around them and perceive its color and light characteristics in a completely different way: their ability to recognize and distinguish colors, shades, and chromatic contrasts changes.

Researchers often compare changes in color perception in older people with tritan color vision defect (dysfunction of retinal cones that are sensitive to the blue-yellow spectrum), since the mistakes they make in color discrimination are very similar (see, eg: [59; 76; 93]).

In terms of color, all perceived images appear darker for older people [48; 84], colder, and less active (see, eg: [68]). They perceive blue as greenish, and green as bluer [29] and more yellow [44; 93].

Since the lens of older people produces more light dispersion than the lens of younger people [26], changing the visual acuity and causing the blurring effect [82], the purity of the observed shades decreases [50]. The shades are perceived as less saturated [68], and

this effect is enhanced by the perception of small objects and excessive lighting, which is characteristic of modern rooms [50].

Changes in color perception lead to the fact that older people often confuse colors, which for young people look completely different. Especially often – yellow and white, blue and green, dark blue and black, purple and dark red [51]. They have difficulty in recognizing mixed colors – blue-green, yellow-green, orange [73] – and are less able to distinguish green, blue, violet [89; 92] and all dark shades [69]. Most of the mistakes they make are related to the perception of hue and chromaticness; least of the mistakes they make are related to the perception of lightness [92]. The most difficult to name areas for this age cohort are dark purple (females make mistakes in color naming in 94% of all cases, and men – in 89%), light pink (73% of mistakes in females and 79% in males) and turquoise (57% – in females and 55% – in males) [89].

Pupil constriction makes the color perception of older people more sensitive to light conditions than the color perception of younger people [82]. Older people are more sensitive to a lack of light in a room than young ones and adapt to such conditions much longer [69].

Moreover, older people perceive differently the color of electronic products which they see on monitors of various devices (computers, tablets, mobile phones, etc.) [87; 94]. The results of older people were significantly worse than the results of the young ones in the experiment [94], where elderly ($N = 17$, 61–74 years old, 5 males and 12 females) and young people ($N = 30$, 20–27 years old, 14 males and 16 females) were shown color samples of saturated gray, red, yellow, green, and blue and were asked to find their matching among a number of color samples on the tablet (APPLE IPAD2018 AIR2) and computer (QUATO-220ex) screens. In their responses, there were more deviations from the correct color along the lightness axis (L^*) chromatic of the CIELAB system, which, most likely, has physiological reasons – associated with a deterioration in the ability to distinguish between shades and a decrease in sensitivity to changes in the chromaticity index (chroma). In addition, the responses of the older people were noticeably "shifted" from red to green (along the A^* axis), which can be explained by a change in the spectral response of the retinal cones.

An interesting point is the fact that, as a result of the adaptation processes, in the course of normal aging, people do not realize that all these changes are taking place with them and believe that their color perception remains the same throughout their life [51; 27]. The human eye adapts to the noted physiological changes and compensates for them due to the phenomenon of long-term chromatic constancy [47], due to which the perceived color of objects appears to be approximately the same throughout life (for example, a person sees a sheet of white paper as white regardless of age).

However, research shows that physiological changes in color vision make older people less likely to perform on various kinds of learning tasks. They perform worse on tasks related to visual images. They need more time to see, distinguish, and identify objects and signs [82]. The rate of reaction to gray and blue stimuli changes especially strongly with age [82]. At the same time, this ability in old age is highly dependent on lighting conditions [50].

(1.2) Methods for reduction of physiological barriers to perception

The researchers give a number of important recommendations that should be taken into account both in the design of classrooms [38] and in the development of virtual training courses, presentations, and textbooks for students of "silver" age to reduce physiological barriers to perception and increase the availability of information in the educational space for older people.

First, it is recommended to use primary colors (red, yellow, or blue) for the design of educational material, since older people recognize them much better than mixed colors [89; 90; 38].

Second, it is recommended to highlight small details and elements with bright shades of the mid- and long-wavelength parts of the spectrum – yellow, red, orange [92], which older people see better.

Third, since in old age all shades are perceived as less saturated, it is recommended to use intense shades and avoid subdued ones to highlight small details, mark text, and improve orientation in it [68].

Fourth, since one of the results of age-related physiological changes in the organs of color vision is a decrease in chromatic sensitivity, for successful pattern recognition and understanding of visual information, elderly people require a well-distinguishable contrast between the figure and the background [43; 56]. In the design of educational materials, regardless of hue, it is recommended to use a stronger level of differences in saturation and lightness [90] shades that are used in combination. It should be borne in mind that to facilitate visual perception, older people need about 3.5 times stronger contrasts than young people aged 20 to 30 years [64, p. 130-132].

Fifth, the researchers recommend avoiding the combinations of shades that look similar – white and yellow [51], green and blue [82], dark blue and black, brown and purple, blue and gray [51; 82], when shaping an educational environment for older people. The use of blues and greens is recommended with only a strong contrast in lightness [38]. For example, to make it more appropriate for older people to perceive a political map, where color is used to show the boundaries and locations of individual countries, it is better to avoid in the designation of neighboring countries those colors that older people do not distinguish well (for example, blue and green or purple and brown) [58].

(2) Educational psychology of color

(2.1) Effect of color on the attention of older people

Recent studies convincingly show the importance of color in visual information processing, increasing its attractiveness and the formation of exogenous attention, which in modern cognitive science is interpreted as the attention of "external origin" attracted and controlled from the outside, and in this regard, opposed to endogenous attention, controlled by the cognizing subject itself (see, eg: [32; 35; 63]). The focus of research interest in such works is aimed at exploration of the possibilities of using color in managing the cognitive abilities of older people, which directly affect the way they perceive information, concentrate, remember, think, and understand educational tasks.

The metaphor of searchlight proposed in the works by Posner and Nissen [75] is used in most of such studies as a methodological prism for understanding the mechanisms of attention, and in the development of the experimental and research paradigm, they are based on the "cue" method. According to this concept, attention refers to the cognitive processes of selecting information from the environment. Paying attention to certain points, which the authors of the theory call "cues", a person selects a certain piece of information to process it in the cognitive system. In this sense, attention is like a searchlight, the beam of which moves in the space surrounding a person, sequentially "highlighting" different parts of the visual field, and the effectiveness of information processing largely depends on where exactly this beam is directed.

Experimental studies of recent years show that for older people, color is one of the main "cues" that contribute to more effective assimilation of new knowledge and skills [36]. The

same color cues that are actively used in the design of the environment for people with reduced vision (for example, coloring individual elements with a bright or contrasting color) are well suited for managing the attention of older people [36].

At the same time, with age, not only the very presence of the color cues but also their quality – quantity, shape, and chromatic properties become increasingly important. If in the early studies of the role of color in attention attracting, the main research question was whether it is necessary to use color in teaching adults (see, eg: [42]), now the question is which colors are better to use. In particular, it was found that gray and beige colors reduce attention and concentration (cited in: [81]). Warm colors, such as yellow red and orange, affect attention much more than cold colors, such as brown or gray [46].

(2.2) Effects of color on the memory of older people

Color helps to remember certain information by drawing attention to it. The difference in the degree of attention to certain stimuli increases the likelihood of what kind of information will persist in memory: the more attention, the stronger the memories will be [70; 78].

According to experimental research, the presence of color "cues" significantly improves the performance of a variety of tasks related to memorization [40; 79; 88], even with cognitive impairments [33]. With color cues, people of the old (65–74 years old) and great (over 75 years old) age best remember the area in virtual simulations [37]. They recognize familiar objects and shapes faster [89; 90], pass the word memorization test more successfully [72], and memorize images better, especially if they are colored yellow, red, or green (blue images are less memorized) [71].

Colored objects are remembered better than black-and-white ones, because color has a special status and in memory processes, when memorized, it makes the so-called "color superiority effect" (see eg: [31; 88]), the essence of which is that color influences the formation of additional mnemonic traces, which are important for the successful extraction of the necessary information in the future. Everyday experience shows that colored objects are easier to spot in ordinary physical space. Roughly the same thing happens with memory: colored objects are easier to find and retrieve (see, eg: [30]). Color is an important resource for successful recognition of objects and images [89] and it contributes a lot to the work of memory associated with encoding and retrieving information (see, eg: [36; 61; 66]).

It should be mentioned that different types of color memory (voluntary and involuntary) change to varying degrees with age. Older people remember color well automatically, unconsciously, and without noticing it, and this involuntary color memory is of great importance for memory productivity, affecting memory readiness, the speed of remembering and forgetting. However, voluntary color memory – memorizing with a special attitude to remember a certain shade and requiring certain volitional efforts – noticeably worsens with age (see, eg: [71; 73]). The changes in males are more noticeable than in females. The shades of the blue-green, purple, and pink parts of the color spectrum are the most difficult for older people to remember; they find such shades worst of all among the specimens they have seen, even if they are shown to them just a few minutes before [73].

(2.3) Impact of color on the emotions of older people

According to the research, the stability of memorization is associated with the affective tone of information and is enhanced by the simultaneous work of different types of memory, primarily – emotional, figurative, and verbal-logical [55; 62]. Emotionally colored information becomes a priority for cognitive processes: it is absorbed faster, perceived

better, and retained in memory longer (see, eg: [63]). Since color is most directly related to emotion (see eg: [52]), it can be a powerful trigger for triggering cognitive responses.

Despite the fact that the strength of emotions associated with colors and shades gradually weakens with age (see, eg: [68; 95]), in old age the emotional response to color is well preserved, which is important in the learning process for activating memory [52; 60; 85]. Colors and shades continue to elicit robust emotional responses in older adults, which researchers recommend using to increase learning intensity. Unlike young people, who remember negative events faster and better, older people absorb positively colored information better. Different colors also evoke an unequal response in strength [40].

An effective mechanism for activating the emotions necessary for the consolidation of information is associative connections, which in modern pedagogy are increasingly used as a mnemonic teaching technique (see, eg: [19]). Analysis of the scientific literature on existing color associations and their influence on cognitive processes in older people shows that color-related conscious and unconscious meanings have a pronounced age-specific character [68]. Associations with warm and cold, active and passive, as well as with the color names green and blue change most with age, which, according to researchers, is due to the fact that older and young people imagine these colors in fundamentally different ways. Young people think of deep blues with low saturation (dark and pale blue), while older people think of bright blue. As a result, young participants are much more likely to associate this color with sadness. Older people imagine green as yellowish and, as a rule, describe it as warm and light [49].

To improve the effectiveness of learning in older people, researchers recommend influencing cognitive processes by changing the emotional context with the help of color, in particular, making it more positive (see, eg: [34]). For example, the use of green in the design of presentations, teaching aids, and other educational materials, which has positive connotations in older people and improves their retention of information (see eg: [62]). Colored text is unlikely to affect memory in any way, while properly colored diagrams, images, or symbols can be an important tool in the development of color-coding strategies for memory improvement [71].

(3) Pedagogical color sociology

(3.1) The role of color in the lives of older people

The research carried out within the framework of the sociological approach and the emerging color sociology has made an important contribution to the study of color in educational environments for older people. Such studies are most often conducted using survey methods and are aimed at understanding how older people themselves assess the role of color in their lives, what changes in color perception they notice and how this affects their social activity.

Surveys of older people show that most of them love color and consider it to be a factor significant for the improvement of their life quality (see, eg: [51; 90]). They note that color increases the readability of the space, helps them to orientate [51], find the required objects, and even improves their mood and well-being [36].

Best of all, according to older people themselves, they see red and yellow colors, as well as rich shades. Red, yellow, and orange attract their attention and improve mnemonic abilities – help to memorize and remember [36].

Most older people are confident that they see colors the same way as in their youth, but at the same time, they complain that they can hardly distinguish the inscriptions on the

screen of electronic displays and have difficulty in reading, if the text is not black, but yellow, red or blue on a white background [51].

(3.2) Color preferences of older people

The research in the field of color preferences – subjective or collective color sympathies, expressed in a certain ranking of primary colors and their shades – is of great importance for the development of the educational environment of the third-age institutions, gerontologically oriented educational sites and textbooks.

Interestingly, in contrast to physiological changes in color vision, unnoticed by most older people, the difference in color preferences is obvious to them. They are confident that their favorite colors are different from the color preferences of today's youth, and note that their own chromatic taste has changed with age: they began to like completely different shades, not the same as they used to like in their youth (see, eg: [39]).

Older people are very judicious in their choice of colors. They note that their preferred colors are associated not only with different objects but also with aesthetic categories. Therefore, when deciding which color to choose, they analyze not only their subjective and, often, emotional attachment to certain shades. An important and often decisive role for them is played by how much the color they like best suits the setting, how it will look, and how others will perceive it. If necessary, they are ready to choose a shade less preferable, but more suitable for the situation [8; 36].

Color preference research has traditionally been focused on two main questions: what colors do older people like best and why they choose them. Most of the studies in this group study the color preferences of older people by experiment, asking the participants to arrange colored cards in order of decreasing attractiveness. The number of color samples and color systems used may vary.

Experimental studies carried out in different cultures (see, for example, the studies of elderly Russians [8], Germans [39; 41], Taiwanese [45; 57], Hungarians [67], Swedes [91; 92], Chinese [95]), convince that color preferences change with age in the same way. The preference for blue-violet and rich yellow shades is sharply reduced. On the contrary, the popularity of red, orange, and green colors is increasing markedly. In addition, the preference of the shade groups changes. Older people like light shades less and more dark and muted shades.

Researchers associate these changes not only with the action of biological and psychological factors – age-related changes in the lens (see, eg: [26; 68]), a change in metabolic intensity, and a decrease in motivation [39]), but also with a difference in experience and lifestyle [29]. Most of the studies conducted to date suggest that older people develop a specific chromatic taste that distinguishes them from younger age groups. Older people are literally rediscovering color. They perceive color images in a fundamentally different way and process the information they receive differently, since earlier, for example, in the "beige" 1970s or "black" 1980s [2, p. 30], there was much less color than it is now. As the technological complexity of culture, its representatives increasingly have to distinguish objects by color [18].

(3.3) Architectural Gerontology

A number of important issues of choosing the color of educational institutions and coloristics are being developed in theoretical and practical studies of architectural gerontology, the representatives of which unanimously consider color as an important tool

that makes it possible to create an internal environment of classrooms visually comfortable for an elderly person [38; 53; 77].

In regulatory documents, the term "visual comfort" is defined as "people's satisfaction with the internal visual environment of a room, expressed by the level of illumination, light brightness, visibility, reflection and psychological and physiological sensations from natural and artificial lighting" (see eg: [4]).

Empirical research in this area convinces that the aging of an elderly person's body inevitably leads to the need to adapt the color characteristics of the living and public space actively used by older people to their specific needs (see, eg: [6; 7; 38]).

A certain contribution to the development of this part of the problem has been made by the studies on the use of color in the design of medical institutions intended for older people, where the effect of color on the well-being and comfort of the elderly is considered proven [38; 65; 85].

This group's research contains a number of color imperatives for gerontological education infrastructure, most of which concern the necessary limitations of the chromatic palette and acceptable color combinations. The authors strongly advise against the use of dark colors in the design of classrooms for older people, since they create a sense of a closed space and are poorly perceived by older people [82], as well as the colors with high saturation, which cause increased arousal in older people [38]. It is recommended to choose for the walls of classrooms light shades that reflect light well, primarily yellow; use warm pastel colors, as well as restrained, calm and soft color nuances [28, p. 89–90] or shades of the blue-green part of the spectrum average in intensity and saturation [64, p. 130-132]. Since older people are more sensitive to glare, it is recommended to make all large surfaces matte and protected from glare [64, p. 131], and due to the fact that they perceive depth worse, it is not recommended to use floor coverings with a large pattern [64, p. 132].

Many of the provisions of architectural gerontology are legally enshrined in codes of practice and regulatory requirements (see, eg: [22; 23]).

Conclusion

This review makes it possible to draw a number of important conclusions about the state of research related to the development of color content in the educational environment for older people and the possibilities of their using in educational practice.

First, to date, a large number of empirical studies of age-related characteristics of color vision, color perception, the cognitive potential of color, color preferences and associations have been accumulated. All these works convincingly show that the ability to process efficiently chromatic information remains in old age despite significant age-related changes in color perception and color discrimination. The teacher's understanding of the specifics of physiological changes in color vision in old age and consideration of their influence on the possibilities and characteristics of the perception of educational material in the learning process can significantly reduce physiological barriers to perception and increase the availability of educational information for older people.

Second, most of the studies affecting various aspects of the effective use of color in the educational environment for the elderly relates to the biology of aging and geriatrics and describes involutive and age-related changes associated with color vision at the subcellular, cellular, tissue, organ, and systemic levels of the human body (see sections 1.1 and 1.2).

All these works give a good idea of how older people perceive the color characteristics of the educational space and, in this sense, make an important contribution to the solution of one of the key problems of pedagogical physiology, which is to develop the physiological foundations of the effective organization of the educational process and the physiological substantiation of new methods of learning (see, eg: [5; 12]).

Third, the authors of the works presented in the review unanimously consider color to be an important tool for stimulating cognitive motivation and the level of reflexivity in older people. In this regard, an urgent direction of modern research is the study of ways to increase the effectiveness of memory and memorization of information in older people using color. However, according to the analysis of available research, the effect of color on the attention of older people is much more actively studied in the fields not related to education: in marketing and advertising communications, where such studies help to effectively use color as a powerful means of incitement of the interest and formation of the desired attitude of this age group towards the promoted product.

Fourth, the studies presented herein belong to different fields of knowledge – optics, image processing, neuroscience, sociology, psychology, geriatric medicine and health sciences, architecture, design, and pedagogy. Despite the inevitability of interdisciplinarity in the study of the color content of the educational space for older people, the plurality of sciences and approaches brings some chaos. Until now, different angles of analysis of chromatic communication in old and great age, scattered in different directions and sciences, have not been brought together. The abundance of empirical data of a predominantly psychological orientation requires adequate theoretical understanding. Neither domestic nor foreign pedagogical science has yet conducted such systemic studies. There is still no fundamental analysis of chromatic communication of elderly and senile people as an independent cultural phenomenon.

Fifth, the results of the studies presented in the review convince that the color "correction" in the educational environment intended for older people is not associated with large money, time and effort expenditures, but it can cause noticeable changes in the quality of education at several levels at once – biological (increasing the availability of information and significantly reducing physiological barriers to perception), psychological (supporting and strengthening the processes of memorizing and processing information, increasing the psychological comfort of the educational environment), and social (improving the life quality of older people).

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