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AN INNOVATIVE STRATEGY FOR DETERMINING THE LEVELS OF SCALE RATIO BETWEEN ART OBJECTS AND INTERIOR SPACE

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Abstract. The article presents an innovative decision-making strategy for determining the scale ratio between art objects and interior space, aimed at enhancing the spatial perception of art and interior design. The study employed a structural approach, which included a critical analysis of theoretical and practical materials, experimental design, on-site measurements of the primary scale ratios between art objects and interiors, as well as the involvement of respondents for visual evaluation of the data. An analytical approach was also used to systematize, generalize and compare the collected data. The study identified numerical coefficients that define scale levels, offering a structured approach to making design decisions. As a result, three universal levels of optimal scale relationships between art objects and interior space were formulated, which can be used in designing interiors of various sizes: I Max - for large spaces of public interiors; II Intermediate - for small spaces of public and residential interiors; III Min - for small spaces of residential interiors. The implementation of the obtained results demonstrated the effectiveness of the developed approach and allowed us to conclude that for interior designers it can become a tool that allows creating functionally efficient and maximally harmonious spaces for human life.

Keywords: *Art object, levels of scale ratio, visual correction, interior space, design.*

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1. Introduction

In the modern world, various works of art play an increasingly important role in creating unique and expressive interiors of various types and purposes. When designing an interior, it is important to consider that each piece of art has its place and meaning, which should be determined early in the design process. One of the most important aspects is to determine the ratio of the size of the space and the size of the art object to select the required distance of perception in order to obtain the desired impression. A certain distance to the work of art depends on the size of the space and provides the necessary visual effect, color and shape transmission, clarity of details and creates the overall aesthetic value of the space, creates a certain visual atmosphere. This is also confirmed by the concept of eco-friendly interior design, which is aimed at creating comfortable, functional and aesthetically attractive spaces in various types of premises, as well as achieving visual harmony and well-being when interacting with the environment (WELL, 2024).

Modern scientific research shows that viewing distance and scale of paintings influence the viewer's perception and interaction with art. When choosing and placing objects in the interior, including works of art, it is important to consider their location,

scale and proportions in order to create a harmonious and complementary combination. These findings are supported by scientific results, including surveys of respondents (Okeke *et al*., 2019). Research highlights the interrelated influence of viewing position and spatial scale on art perception, with spatial scale playing a more significant role when viewing paintings up close (Trawiński *et al*., 2023). Carbon finds a linear relationship between the size of a painting and the choice of viewing distance in museums, where visitors often choose their viewing distance intuitively based on the size of the painting: the larger the painting, the greater the distance for comfortable viewing (Carbon, 2017). Scientific experiments have found a strong positive correlation between canvas size and viewing distance in the context of art perception (Yang & Kawabata, 2024). Research shows the psychological and emotional impact on viewers when viewing paintings in galleries, which depends on the physical characteristics and statistical properties of the paintings, such as the size and style of the painting. The context of the presentation (gallery or laboratory) also affects the perception of paintings depending on their physical characteristics. Individual paintings can significantly influence the behavior of the viewer (Estrada-Gonzalez *et al*., 2020). The results of the research expand scientific understanding of the use of distance perception in various fields, including fine art and design, from a neuropsychological perspective. Scientific experiments demonstrate a neural representation of object size that is formed based on visual experience, illustrating the brain's ability to adapt its perceptual mechanisms depending on personal experience (Magri *et al*., 2021). Research also highlights the importance of taking into account psychological aspects such as form perception. When designing interiors and buildings, the influence of architectural form on human perception and behavior is demonstrated (Li, 2019). The researchers apply the "Construal level" theory and argue that psychological distance influences how people interpret and interact with objects, including works of art, with perceived size and distance being related. Understanding this can help in presenting works of art to optimize their reception by viewers (Durkin *et al*., 2020). Scientific experiments and their analysis show that the human ability to estimate distance based on the size and position of an object in a two-dimensional image is limited, which may indicate the independence of the processes of size and distance perception (Kim & Harris, 2022). Research results show that the perceived size of familiar objects depends on their actual size. Larger familiar objects are overestimated by 5% (assimilation), while smaller objects are subject to the opposite effect, highlighting the difficulty of visually perceiving size (Smeets *et al*., 2022).

Thus, previous scientific research has actively explored aspects of the relationship between the observer's distance perception and various objects, including art objects. Research has been conducted in such interdisciplinary fields as engineering and humanities, sustainable design, psychology of perception, psycho-emotional impact and neuropsychology.

But there is a gap in the study of the levels of scale relationship of distance and size of the art object, which are crucial for the effective use of works of art in interior space. This study differs from the previous ones by the analysis, systematization and identification of certain dimensional features that are combined and generalized into levels of scale relationships of art objects and space. The solution to this issue will allow designers and artists to approach the implementation of their creative concept in design in an innovative new way.

Therefore, the overall goal of this article is to identify the levels of scale ratio between art objects in interior space, as well as the possibilities for its correction.

2. Methodology

This study used methods based on analysis and a structural approach to the material under study, with the help of which significant results were obtained and the necessary conclusions were formulated on their basis. The methodological basis for studying and solving the problem posed consisted of:

- The method of critical analysis of bibliographic sources allowed us to identify key aspects of the research topic and focus on current issues in the field of art perception. The analysis showed that to date there are no similar works that would be devoted to the issues of determining the levels of scale ratios and coordinating the sizes of an art object and space, which emphasizes the uniqueness of this work in comparison with previous studies.
- The method of natural research was employed to investigate the relationship between the size of an art object and the interior space, enabling the collection of essential data for determining the study's results. This method was applied in 27 different premises. The research process involved the use of tools for precise measurement of art objects and interior dimensions, including a laser tape measure, a ruler and the recording of dimensional data. The analysis of the results after measurements and data recording facilitated the acquisition of numerical data on the sizes of the art objects and the dimensions of the space.
- The method of visual assessment was utilized to obtain data from respondents in accordance with the research objectives. The study involved 36 respondents, including 6 specialists in the field of design and fine arts and 30 students of the design faculty of KNUCA (Kyiv National University of Construction and Architecture). Each participant was asked to evaluate a certain situation from the point of view of perception and determine the degree to which it corresponds to the expected effect. The data obtained allowed us to analyze the features of perception and their influence on the overall impression.
- The 3D modeling method was also used to confirm the numerical data, the results of which are reflected in the form of visual graphic images. The actual data substantiated the instrumental basis for studying the ratio of the sizes of the art object and the interior space. A detailed description of the procedures is reflected in the Results section.
- The method of systematization was used to summarize and compare the results obtained. In combination with the analytical approach, this method was used to solve the main task of the study - determining the levels of scale and adjustment, as well as formulating the main conclusions and providing the necessary recommendations for designers in design solutions.

To confirm the reliability of the obtained results, the findings were implemented into creative practice. This allowed for an evaluation of the effectiveness and practical applicability of the identified scale ratio patterns. The success of the implementation was demonstrated by applying these patterns to interior design projects of varying functional purposes and dimensions in Kyiv, Ukraine.

This study also used the results of the authors' previous works, which laid the theoretical basis for solving the identified problems (Polubok & Pylypchuk, 2023).

3. Results

3.1. Background and rationale for the results

Outstanding artists and theorists of fine art from different eras have established that the size of architectural details and any works of art in architectural space directly depends on the distances of perception and therefore on the size of the space in which they are placed (Vitruvius, 1914). Leon Battista Alberti noticed that a certain distance from a painting affects its perception. He argued that in order to create the illusion of reality, a painting must be viewed from a certain point of view (Alberti, 1966). Leonardo da Vinci argued that an artist must be three times as far away from the object when drawing from life (da Vinci, 1835).

Arnheim proves that the first thing that is perceived in any object, especially at a distance, is the largest size of the object (Arnheim, 1977). Perceived size and distance are visual quantities. Perceived size is assessed relative to familiar units of measurement (meters, centimeters), while distance is perceived as shorter than it actually is (Higashiyama & Adachi, 2006). The human brain uses monocular cues to estimate distance by detecting activation of specific brain regions during relevant tasks (Berryhill & Olson, 2009).

Modern scientific sources claim that among the many objective properties of any object for visual perception, the most important is its largest size and only then its geometric basis (Yang & Kawabata, 2024). Also, physical size affects the perception of distance to the painting (Estrada-Gonzalez *et al*., 2020). The viewing position (near or far) and spatial scale (size) of paintings influence how people perceive them: larger paintings attract more attention than smaller ones (Trawiński *et al*., 2023). It was also found that the height of a painting requires a greater viewing distance than the width of a painting of the same area. Today, there is a confirmed aspect ratio hypothesis, which explains that paintings with greater height require a greater viewing distance than paintings with greater width for the same canvas area. This is because the human visual field is wider horizontally than vertically (Yang & Kawabata, 2024). The main conclusion is that knowledge of the actual size of an object plays a key role in shaping its perception, highlighting the interaction between familiarity and visual perception (Smeets *et al*., 2022).

Accordingly, the characteristic features of the ratio between an art object and space consist of the principle of scale proportionality of a given object and the interior space, which is achieved by establishing a scale relationship of certain sizes of art objects, the distance of their perception and the interior, correcting the scale of space, its visual reduction or increase with the help of an art object. An important and primary task is the systematization of the general scale ratio - calculation of the size of the art object depending on the dimensions of the space and therefore the distance of its perception. The principle of scale relationship in the object-space relationship is always based primarily on factors of visual (physiological) and psychological perception.

3.2. Determination of the scaling ratio and correction levels

Based on fundamental works, it has been established that the optimal distance for the full perception of an art object in space and sufficient distinction of its details is a distance of three largest (height or width) dimensions of the art object and this is an angular size of approximately 18° (da Vinci, 1835; Stepanov, 1984). At such a distance,

any object is completely distinguishable together with the surrounding space, quite clearly revealing the silhouette, detailing and light and shadow (in the case of a volumetric form), which allows us to recognize the character of the plastic or coloristic visual form.

Thus, it is possible to establish a direct relationship between the size of an art object along its longest side - (h) and the optimal distance of its perception - (L). In proportional ratio, the optimal distance of perception of an art object is three sizes of this art object along its longest side, which is expressed by a certain formula:

$$L = 3h, \tag{1}$$

where (h) is the size of the art object along its longest side;
(L) is the distance of perception of the art object;
(3) is the coefficient (k) of the ratio of the distance of perception and the size of the art object along its longest side.

Using this formula, it is also possible to find and calculate the optimal size of an art object based on its largest side:

$$h = \frac{L}{3}. \tag{2}$$

Based on the conducted field experiments, as a result of generalization, systematization and on the basis of the identified optimal scale ratio of the art object-space, the levels of the optimal scale ratio were determined:

- I Max - corresponds to large sizes of art objects in large-scale public interior spaces;
- II Intermediate - corresponds to the average size of art objects in residential and small public interior spaces;
- III Min - corresponds to small sizes of art objects in living interior spaces.

One of the main features of using art objects in the interior is the method of correcting the scale of space using art objects and deliberately violating the optimal levels of scale ratio. Correcting the scale of the interior solves specific and special problems in design, the purpose of which is to visually increase or decrease the scale of space. For example, research in this context confirms that incorrect perception of the scale of an art object will lead to incorrect perception of the size of space (Kim & Harris, 2022).

A large space does not always impress with its colossal dimensions, it seems visually smaller than its actual parameters and has a false scale if the art object placed in it is too enlarged in its largest size for optimal perception in such an environment. In turn, an art object that is large in its actual size does not impress with its dimensions when it is placed in a huge space that visually significantly exceeds the optimal scale ratios and “oppresses” even the large parameters of the art object. By deliberately violating the optimal scale ratio of the art object with the space, by visually correcting its own dimensions, it is possible to visually increase or decrease the dimensions of the room, thereby expressing a deceptive or creating an indefinite scale of the interior.

Based on the identified optimal scale ratio between object and space, additional possibilities have been developed - visual correction of the size of the interior using art objects, which is necessary for special tasks - visual distortion of the scale of space.

The next key point of the study was the determination of correction levels. For this purpose, coefficients corresponding to each of the three correction levels were determined, which were based on the levels of the optimal scaling ratio.

In order to visually enlarge the space, it is necessary to create a significant difference in the ratio between the distance and the size of the art object, the coefficient equal to 3 must be increased by 4 times, where the art object must be significantly reduced in comparison with the size of the space. In turn, for the task of visually decrease the space, where the art object must be significantly increased in comparison with the size of the interior, the basic coefficient equal to 3 was reduced by 4 times. As a result, numerical values (proportionality coefficients (k)) were obtained for certain levels of visual increase/decrease of interior space. The identified levels of space size adjustment were also assigned conditional names - I Max, II Intermediate, III Min.

To find the numerical proportionality coefficient required for the task of visually increasing the interior space, the following equation was developed and applied:

$$k = 3i + 3, \tag{3}$$

where (i) is a variable index with values 1, 2, 3, which were used for calculation according to certain levels: 1 - for III Min, 2 - for II Intermediate and 3 - for I Max.
(k) is the coefficient of the ratio of the perception distance and the size of the art object on the largest side, which corresponds to a certain level.

The resulting coefficients, corresponding to the correction levels for visual increasing of space, will include the following values:

- $k_1 = 6$;
- $k_2 = 9$;
- $k_3 = 12$.

To visually decrease the interior space, the following equation was developed and applied:

$$k = \frac{3}{4}i, \tag{4}$$

where (i) is a variable index with values 1, 2, 3, which are used in accordance with certain levels: 1 - for I Max, 2 - for II Intermediate and 3 - for III Min.

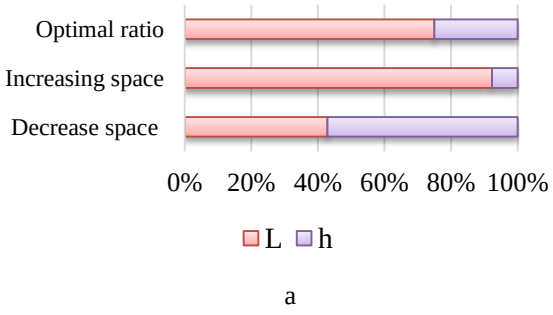
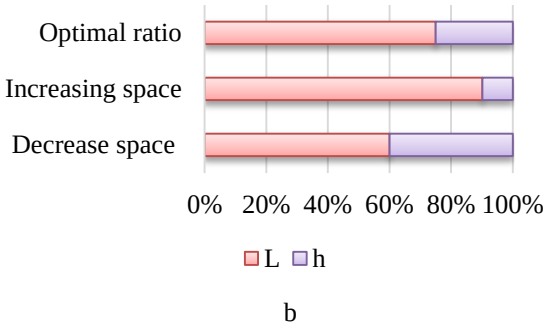
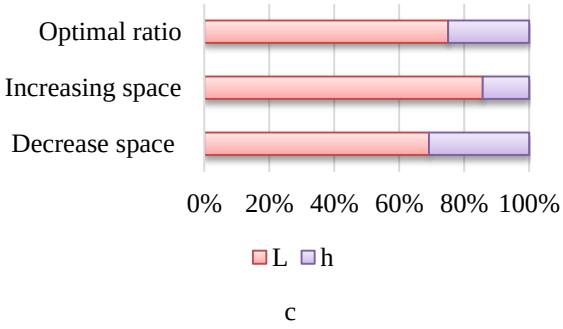
- The resulting coefficients, corresponding to the correction levels for visual decrease of space, will be formed from the following values:
- $k_1 = 0{,}75$;
- $k_2 = 1{,}5$;
- $k_3 = 2{,}25$.

Thus, to determine the required size of an art object in the interior space, you can apply a universal formula using the numerical values of the coefficients corresponding to certain levels of scale and correction:

$$h = \frac{L}{k}. \tag{5}$$

The result of the systematization made it possible to determine a unified structure of coefficients and the corresponding levels of optimal ratio and correction, where a certain level corresponds to its own coefficients (Table 1).

Table 1. Coefficients and corresponding levels of optimal scale ratio and space correction

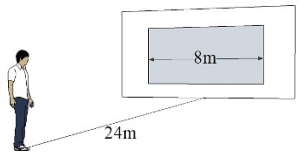
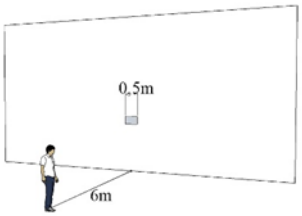
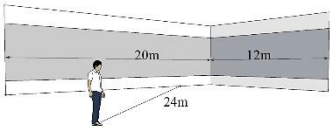
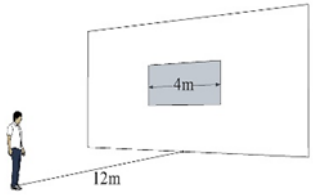
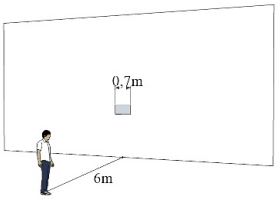
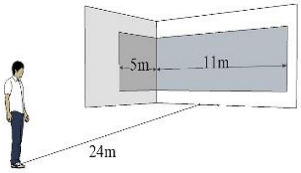
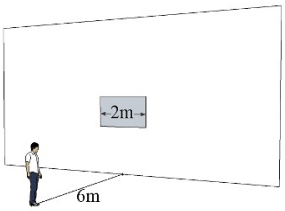
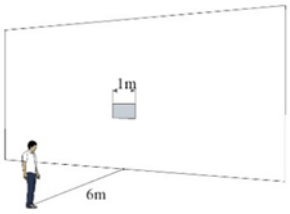
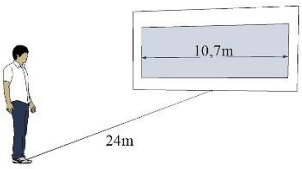
Levels	Coefficient (k)			Histogram of optimal ratios and space correction (L:h)
	Optimal ratio	Visual correction of space		
		Increased	Decrease	
I Max	(k = 3)	(k = 12)	(k = 0,75)	 a
II Intermediate	(k = 3)	(k = 9)	(k = 1,5)	 b
III Min	(k = 3)	(k = 6)	(k = 2,25)	 c

Source: Table 1 and illustrative schematic images (a-c) - developed by the authors

Based on the results presented in Table 1, it should be noted that the coefficients of the identified correction levels I Max, II Intermediate, III Min (with an increase/decrease in space) have a positive dependence with a proportional change in values. The coefficients at the optimal level of the ratio remained unchanged.

As a result of systematization of the obtained data, the levels of the optimal scale ratio of the art object to space and visual correction of the size of the space were determined (Table 2).

Table 2. Levels of optimal scale ratio and visual correction of art object-space

Levels	Optimal scale ratio and visual correction of space size		
	Optimal ratio	Visual correction of the size of space	
		Increased (using the example of a distance of 6 m)	Decrease (using the example of a distance of 24 m)
I Max	 a	 b	 c
	24≤:8≤ (k = 3)	6: 0,5 (k = 12)	24: 32 (k = 0,75)
II Intermediate	 d	 e	 f
	12–24: 4–8 (k = 3)	6: 0,7 (k = 9)	24: 16 (k = 1,5)
III Min	 g	 h	 i
	≤6–12: ≤2–4 (k = 3)	6: 1 (k = 6)	24: 10,7 (k = 2,25)

Source: Table 2 and illustrative schematic images (a-i) developed by the authors

It is necessary to take into account that the table shows only conditionally selected ratios of distances and sizes of art objects. When implementing a design solution (any size of space and art object), it is recommended to use a coefficient that is determined for each level of the optimal ratio of the art object and the interior or visual correction of the size of the space.

The following characteristics correspond to the levels of optimal scale ratio and correction of the size of space I Max, II Intermediate, III Min:

Level - I Max.

▪ The first level (I Max) of the optimal scale ratio corresponds to art objects (from 6-8 m and more on the long side) and designed for perception from large distances (12-

24 m and more). It is used mainly in large-scale spaces of public interiors (Table 2, image (a)).

▪ The first level (I Max) of space enlargement corresponds to art objects (0,5 m on the long side) designed for perception from short distances in small-sized rooms (perception distance 6 m), for maximum visual enlargement of interior space. It is used mainly in small-sized spaces of residential interiors (Table 2, image (b)).

▪ The first level (I Max) of space decrease corresponds to art objects (32 m on the long side) designed for perception from large distances (perception distance 24 m) and for maximum visual decrease of interior space. It is used mainly in large-scale spaces of public interiors (Table 2, image (c)).

Level - II Intermediate.

▪ The second level (II Intermediate) of the optimal scale ratio corresponds to art objects (from 4-6 m on the long side) designed for perception from a distance in relatively small rooms (6-12 m). It is used in residential and public interior spaces (Table 2, image (d)).

▪ The second level (II Intermediate) of space enlargement corresponds to art objects (0,7 m on the long side) designed for perception from short distances in small-sized rooms (perception distance 6 m), for an average visual enlargement of the interior space. It is used mainly in small-sized spaces of residential interiors (Table 2, image (e)).

▪ The second level (II Intermediate) decrease in space corresponds to art objects (16 m on the long side) designed for perception from large distances (perception distance 24 m) and for the average visual decrease in interior space. It is used mainly in large-scale spaces of public interiors (Table 2, image (f)).

Level - III Min.

▪ The third level (III Min) of the optimal scale ratio corresponds to art objects (4-2 m and less on the long side) and those designed for perception from a distance in small rooms (6 m and less). It is used in residential interior spaces (Table 2, image (g)).

▪ The third level (III Min) of space enlargement corresponds to art objects (1 m on the long side) designed for perception from short distances in small-sized rooms (perception distance 6 m), for minimal visual enlargement of interior space. It is used mainly in small-sized spaces of residential interiors (Table 2, image (h)).

▪ The third level (III Min) decrease in space corresponds to art objects (10.7 m on the long side) designed for perception from large distances (perception distance 24 m) and for minimal visual decrease in interior space. It is used mainly in large-scale spaces of public interiors (Table 2, image (i)).

3.3. Implementation in interior design

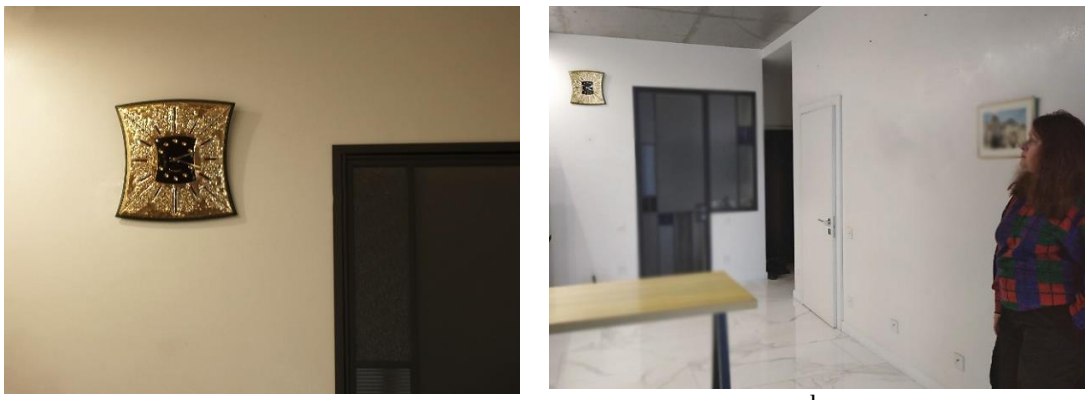
The results obtained during the study required practical confirmation. For this purpose, the identified levels of optimal scale ratio and space adjustment were applied in the artistic design of various types of interiors. Some examples are presented in Figures 1-3.

Figure 1 (a, b) shows the result of applying visual correction of the I Max level of visual decrease of the size of space in the restaurant interior. This example is an artistic painting that completely occupies the ceiling area, thus visually reducing the size of the interior space.

a b

Figure 1. Artistic painting on the ceiling in the restaurant "Azhur", Kyiv, Ukraine.
Artist: Oksana Pylypchuk
Source: Photos (a) and (b) by O. Pylypchuk

Figure 2 (a, b) shows an example of the I Max level of visual increase in the size of the space, which was used in the interior of an office space to visually adjust the size of the interior. The result of the implementation is an art object in the form of a wall clock, which, in comparison with the size of the space of the room, has a smaller size for the perception of the optimal scale ratio. Thus, this object performs the task of visually increasing the space of the interior.



a b

Figure 2. Wall clock "Memories of Venice" in the interior of the Ponyglass Company office space. Kyiv, Ukraine. Designer: Oksana Zakutskaya
Source: photos (a) and (b) by O. Pylypchuk

III Min level of optimal scale ratio was applied in the interior of a residential apartment. The result of this implementation is presented in Figure 3 (a, b). The painting placed in the interior has an optimal ratio of its size with the size of the space and the distance of perception. Thus, the perception of a harmonious scale ratio of the art object and the size of the interior space of the residential apartment is created in the room.

a b

Figure 3. Painting “Flight over the Earth” in the interior of a residential apartment, Kyiv, Ukraine. Artist: Oksana Pylypchuk
Source: photos (a) and (b) O. Pylypchuk

The results of the implementation showed the accuracy of the calculations carried out in the study (within the permissible error) of the numerical values of the levels of optimal scale ratios and the adjustment of interior spaces of various types and functionality. The presented examples clearly demonstrate the validity and effectiveness of using the obtained results as an innovative approach necessary for designing art objects in interiors of different sizes.

4. Discussion

The problems of perceiving objects in space have a long history. In fundamental scientific works, world-famous scientists noted the direct dependence of the perception of works of art on distance and scale. For example, Helmholtz's theory of perception argues that the perception of scale is formed by the brain's interpretation of sensory signals in the light of accumulated experience (Kahl, 1971). Moles studied the relationship between perceived size and distance from a psychological perspective, highlighting how these two aspects are interrelated in visual processing (Moles, 1981). Arnheim, based on empirical data and experiments with perception, established the fundamental and factual bases (which are still relevant today) for the perception of any objects in space depending on the observation distance and their sizes (Arnheim, 1977).

Modern scientific theories also seek to understand the perception of distance and size of objects in the context of determining psychological levels of perception. They study scale as a psychological principle that influences how people perceive and represent the size of objects depending on context and previous experience and how it relates to the organization of visual information by depth or distance from the observer. For example, the “Construal level” theory helps explain psychological distance, as the viewer’s perception of the distance to art objects based on their level of abstraction. The authors found that abstract works of art tend to evoke greater psychological distance (Durkin *et al.*, 2020). The authors hypothesize that adjusting the size and position of an image affects the perception of object distance (Kim & Harris, 2022). In this context, a binocular size perception model is developed based on four angular dimensions and interocular distance (binocular geometry) providing an absolute size metric (Kim, 2017).

In general, understanding the physiology and psychology of perception, which is important for art and aesthetics, helps us explain how we evaluate the size, scale and

distance of objects. This study is the first to propose a system of levels of scale relationship between art object and interior, expressed in real numerical terms. The levels of scale identified as a result of this study may be the missing link in understanding the visual perception of the scale relationship between art objects and interior space.

Considering that the problems of perception can be supplemented by the constant development of new theories and discoveries in the field of visual perception, as well as the constant transformation of visual practices of fine arts and design, this issue is promising and requires further research.

5. Conclusion

As a result of the study, three universal levels were structured, defined and formulated for optimal scale relationships between an art object and space, visual adjustment of the interior size, necessary when solving special problems - visual increase or decrease in the size of the room.

- I Max: maximum level of optimal of scale ratio between the art object and the interior (recommended for use in large-scale public interior spaces), visual increase/decrease of space.
- II Intermediate: average level of optimal scale ratio between the art object and the interior (recommended for use in small spaces of public and residential interiors), visual increase/decrease of space.
- II Min: minimum level of optimal scale ratio between the art object and the interior (recommended for use in small spaces of residential interiors), visual increase/decrease of space.

The proposed scale system is based on numerical values - coefficients found for each level, which are necessary components in determining the desired relationship between the sizes of art objects and the size of the interior.

Thus, the developed system of scale ratios develops and complements one of the problematic topics of the synthesis of arts in the aspect of the relationship of art objects with the subject-spatial environment. Visual analysis of the results of practical application of the developed system of scale relationships of art objects and space, made it possible to recommend this system of scale relationships as an improvement of the theoretical basis of systematization in the general sphere of design methodology. The proposed approach is recommended for practical application - designing art objects of certain sizes in interiors of different types. Accordingly, it can be stated that the definition of the necessary levels of scale relationships of art objects and space, even at the initial stages of design and creative work, can significantly increase the effectiveness of visual ecology and functionality of the interior.

This study is promising and requires further development in the field of the theory of art synthesis, within the boundaries of research into the methodology of visual object-space relationships.

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