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Research Article

Perception and evaluation of interior space: Experimental study on color and pattern

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Abstract
The phenomenon of perception and visual illusion in interior space is a topic that attracts multidisciplinary interest. From the perspective of architecture and design, the complexity of the subject gains momentum, as it is also associated with experiencing the influence of design elements and tools on the quality of indoor environments, which subsequently involves subjective, individual and emotional concepts that play all together an important role as intermediating variables. Aiming to evaluate the experience of interior architectural space, how its properties and visual weight is perceived, a descriptive type of survey research was used to conduct an experimental assessment, with involvement of 93 participants who rated 27 spaces/rooms in eight experiential categories. For the exploratory purposes of this study, a methodology presented by Gerald Franz (2006) was used, who evaluated the perception of space and color, and perceived surface qualities of indoor environments. To achieve an approximative descriptive visual response in this model, the semantic differential was employed as a simple and widely used method. In order to detect the three primary dimensions of emotion as occurring in affective appraisals (pleasure/valence, excitement, and dominance), the combination of pairs of oppositional adjectives with a Likert scale are applied. In addition, ratings of openness and spaciousness were included to detect possible interactions between selected parameters, surface characteristics and experienced space proportions, and ambience.

Keywords: Color, Pattern, Order, Perception, Interior design

Extended Abstract

Introduction: When trying to understand how spatial layout of a room is perceived, interior designers and educators primarily address issues of surface treatment, scale, and proportion. There is a wide consensus that by introducing certain colors or geometrical patterns, physical spatial properties can be visually altered (Stamps, 2005: 736). In specific, color and its influence on space perception and emotions has been identified as a major characteristic, a strong design tool that can add perceived weight to surfaces, alter the basic proportions of a room, and distinctly be a calming or exciting factor. Similarly, pattern as one of the primary characteristics of surfaces, has been greatly studied because it can influence the perception through altered proportional readings of a space (Meyer, 1957: 7-20). Large-scale repeats with complex patterns and contrasting colors may be appealing in a large room but can also create overwhelming emotions in a small one. Patterns with vertical lines may add visual height to a room with low ceilings. Conversely, patterns with horizontal lines can make a room or a piece of furniture look wider (Kilmer & Kilmer, 2014: 128). Castell et al. (2019: 29) on the other hand argue that object-based texture effects cannot be generalized to interior space perception, stating that pattern density impacts visual perception more than pattern orientation. However, there is a limited number of empirical studies that examined the specific ways in which the interior environments are perceived and evaluated.

Purpose and scope: In addition to limited empirical research, it is also difficult to record how interior features of a space impact the perception of users in a systematic way. Therefore, attempting to understand the interaction of color, patterns,

and surface qualities with space, the study presents an experiment conducted by using a 3D modelled virtual room. Spatial models presented to the respondents are all dimensionally equal, with the same position of opening, with dimensions of the room being 4.3m x 5m and height of 2.8m. The opening is 1.5m x 2.2m and the height is positioned at the center of the adjacent wall. In all scenes, the surface of the floor is covered with light wood parquet. The position of the camera is fixed and equal for all scenes and its height was set at the eyelevel, or to 1.6m, which is accepted as the average height. By treating the vertical and horizontal surface of the ceiling with color and/or pattern, a total of 27 scene variations are obtained. 93 respondents were asked to evaluate their perception on the space in four dimensions: valence, excitement, dominance, and spatiality, and eight categories: pleasantness, harmony, excitement, interestingness, obtrusiveness, gravity, spaciousness, and enclosure.

Method: Evaluation of spatial perception is performed by analyzing the effects of advancing and receding colors, large- and small-scale patterns, reflectiveness and refractiveness of surfaces. For the exploratory purposes of this study, the semantic differential as a simple and widely used method for the approximative quantification of emotional responses is chosen (Franz, 2006: 4) conducted with the involvement of 93 participants who rated 27 spaces/rooms in eight experiential categories. The combination of pairs of oppositional adjectives with a Likert scale are used for the three primary dimensions (pleasure, arousal, and dominance) of emotion that occur in affective appraisals (Mehrabian & Russell, 1974: 18) are presented in Figure 1 and Table 1 respectively. It has been argued that such a framework allows effective quantification of affective responses using introspective verbal scale setting. In addition, ratings of dominance and spatiality or openness were collected to detect possible interactions between room color and experienced room dimensions.

Findings and conclusion: The findings confirm that it is challenging to analyze how interior space is perceived from an architectural perspective. An additional challenge is how to record the impact of selected spatial features on the users in a systematical way. The results of the study confirm that color selection is the primary factor impacting perception, particularly valence and spatiality, while the size of pattern was related mostly with spatial proportions and affected perception of dominance and spatiality. Additionally, patterns with strong color contrasts and angular geometry are perceived more as unpleasant and obtrusive, in comparison to small scale patterns, as well as patterns with lower color contrast. Interestingly, there were no significant differences in perception, related to selective coloring of space surfaces in all categories evaluated. Additionally, the study confirms that virtual reality simulations are an extremely useful and effective tool for basic architectural research that enables novel empirical methods to be used in research and results in faster acquisition of findings. In a broader sense, the results of the study also confirm that aspects of perception and spatial experience are analytically investigable and have detectable correspondents in the physical environment and that selected spatial properties greatly influence spatial perception as well.

Keywords: Color, Pattern, Order, Perception, Interior Design

INTRODUCTION

Investigation into how to experience space and evaluate its visual and aesthetic quality in architecture, a rational, technical, and engineering function serving artistic science, has never been a straightforward topic. Throughout history, spatial quality has been associated with universal values of truth, love, and reason, been explained in scientific punctuality of proportion, rationalized through concept of order, and equalized with mathematical lawfulness but it has never been quite fully explained. Contemporary researches have shifted the scholarly focus from scientific rationalization trials to an argument which claims that spatial cognition is not universal, it is rather influenced by multiple social factors such as culture, customs, gender, age, or even professional expertise (Levinson, 2003: 62; Levinson & Wilkins, 2006: 26).

Therefore, understanding the multilayered nature of the subject this study argues that the users respond to physical properties of space with a particular visual and emotional reaction to the environment. Through recent investigations made in virtual environments, researches on the correlation between a physical structure and perception or emotional experience have gained momentum. This virtual experience allows easy simulation and facilitates effortlessly controllable, fast variations of spatial properties, allowing quick evaluations of spatial qualities through individual experiences. Attempting to make reliable predictions on how visual perception can change the understanding and interpretation of an ambiance and space, several factors involved in establishing the composition, which leads to a distinct experience, are parallel presented.

This is done by using both individual and interactive effects of surface characteristics, color, pattern, and finishing properties (reflection and refraction), aiming to assess the experience of interior architectural space

and its visual weight. Selected criteria have been designated because they are the fundamental qualities of our visual perception, which has a straightforward impact on the viewer, spatial quality, and human consciousness, in general. The primary goal is to test the association of spatial properties with visual perception and analyze if and in what way the visual quality of interior space can be improved through the appropriate use of design tools and elements. To achieve that, the study experiments with establishing interrelations between parameters from the simplified component-based spatial model and attributed experiential qualities of interior spaces. In specific, the explorative questions aim to examine the influence of applications of different color categories, pattern and surface finishes on the visual experience, and to understand how design parameters could be considered when attempting to correct the proportions of interior spaces.

Perception and Interpretation in Architecture

"… one was to experiment in the here and now: thus, life was a perceptual experience."
Dan Graham, 1999

In architecture, three-dimensional space is the primary medium, and creation of spatial compositions is the fundamental task. However, its definition as well as the way it is perceived is extremely diverse. The lack of learned or scholarly defined appraisal parameters, units of values, or simply insufficient information and knowledge on the subject of spatial relationships, may restrict the ability to certainly predict the users' respond to a particular space.

Perception is a remarkably personalized and individual experience that is both instinctive and intellectual in character and is tackled from various perspectives, and by numerous professionals. In common terminology, perception is defined as the way one thinks about something and the idea of what it is like the way one notices things as sensory information, or the natural ability to understand or notice things quickly. However, in philosophy, psychology, and cognitive science, perception is viewed as a process that -aside from gaining sensory information- encompasses its interpretation, and how it is evaluated or subjected to a form of judgment (Qiong, 2017: 18). When associating perception with a place, two concepts are identified: emotional perception which involves recording of data and actions that have been attained through senses; and cognitive perception which in addition to sensory stimuli is concerned with the process, the factors that influence how the information is organized and the judgment is formed as an interpretation of the stimuli (Downs & Stea, 1973: 10). Some theories argue that perceptual experiences happen long before "the soul takes notice." (D'Annunzio, 1912: 119). However, the nature of perceptive experience in architecture is immediate, emotive, and even subconscious (Dewey, 1934: 29). The significance of emotional character of space perception is claimed to be biologically derived and largely unconsciously and instinctively determined through evolutionary programming (Pallasmaa, 2014: 233). Emotional sensibility is additionally associated with the concept of "atmosphere" as a form of perception that happens very fast (Zumthor, 2006: 6) and cannot be invalidated as it is a spontaneous reaction of everyone. It is also seen as an immediate and synthetically grasped response to complex multi-sensory stimuli of numerous factors, and interpreted as an overall atmosphere, ambience, feeling or mood (Pallasmaa, 2014: 230).

Contemporary research is focused on the interactions of spatial factors on perception from numerous aspects. Architectural forms and elements have been identified as one of the primary factors impacting perceptive experience, studied through an academic field of environmental or architectural psychology (Hall, 1969; Gifford 2002). Findings of the detailed study on emotional reactions to architectural space geometry suggest that even criteria such as protrusion, curvature, scale and proportion of space influence the use's emotional state and perceptive experience (Shemesh et. al., 2022: 1). Furthermore, planning for senses and experience, has come forward as one of the key considerations to be made by architects in the designing process (Li, 2019: 195). The focus has also been put on the essential role that sensory stimulus in an architectural space has, raising awareness of this complex and somewhat neglected design aspect. A study on participants' visual, auditory, olfactory, and tactile and kinesthesia perceptions in terms of preference and emotion, shows significant differences among participants' levels of sensitivity to different sensory domains, identifying color as the highest of all stimuli (Chen et. al., 2022: 14). In particular, it has been argued that as a single changing sensory stimulus, a dynamically colored light can lead to significant mood fluctuations and changes in the preference level. Interestingly, yellow color has been identified as the favorite color of light (Chen et. al., 2022: 14).

However, perception in architecture is not viewed as a single moment but rather as a process that interprets the logic behind the systems formed in architectural compositions. It deals with how and to what level the viewer is able to organize selected visual information, elements of architecture, into meaningful patterns, which would correlate with the level of achieved visual order, and thus the level of visual quality. “Order” on the other hand is too abstract and a broad term to be successfully defined with a single statement. It is defined as the degree and kind of lawfulness governing the relations among the parts of an entity (Lorand, 2000: 9). The level of order will depend on the degree of conformity and on the level of unity reached in the organization of a variety of architectural elements. The greater the order, the more comprehensive the perception and judgment is. It is claimed that order is achieved when our vision can perceive similarities and differences within a design composition (Bohm & Peat, 1987: 111). Interestingly, Aristotle made a similar claim regarding the definition of beauty, “beauty lies in the recognition of similars within dissimilars” (Smith, 2003: 24). Contemporary research on cognitive perception is more concerned with factors that shape judgment. Culture has been identified as the primary factor influencing sensory information interpretation. Cultural factors provide some of the meaning involved in perception. They are, therefore, intimately implicated with that process (Samovar et al., 1981: 11). In fact, contemporary research puts culture into the center stage as an important parameter in evaluating perception in the architectural arena and achieving long-lasting and socially responsible architectural design. Associating culture with how to perceive and evaluate space seems like a logical connection since perception, as an experience, is never isolated from positive or negative understandings, familiarities, ideas, beliefs, views, and opinions. Such “valued” perception does not deny the role of senses in forming a judgment on the visual quality but attempts to understand how much of it has to do with what people have learned through situations that societies or individuals have been and are exposed to.

The difficulty in defining how space is perceived and reacted to, or if it is an innate of attained skill, has always been a universal debate, addressed by numerous theoreticians, philosophers, anthropologists, visual artists, linguistics and even theologists. Though modern researchers have proclaimed that a single model of positive experience in architecture is a utopian concept, this idea has taken a turn from defining a universal “beautiful form” or positive perceptual response into discovering universal socio-cultural values, leading researchers to the path of comparative cultural analysis (Gonzales, 2003; Gonzales, 2001; Berleant, 2004). In “The Anthropology of Art” Morphy and Perkins (2009: 333) describe a person’s perceptive reaction to an object as being comprised of two parts: the fairly objective perception of the physical characteristics of an object, defining it as noticeable but meaningless; and the relation of those characteristics to a subjective set of cultural connotations; claiming that only upon being processed through their incorporated systems of value and meaning, physical properties of an object take upon aesthetic properties.

Perception of Color and Pattern

Spatial properties undeniably have great emotional potential, particularly those associated with space dimension and size as well as enclosure (Stamps, 2005: 735). In general, rooms that create a sense of spaciousness but still offer sufficient enclosure for protection (Newman, 1996: 18) and privacy purpose, as well as those that provide pleasant vistas, are preferred by the users. But, out of all spatial elements, color and its influence on space perception and emotions has been studied the most. It is a strong design tool, as color can add perceived weight to surfaces, alter the basic proportions of a room, and diversely be a calming or exciting factor. Interestingly, color is defined as a nonphysical property of things but is, in fact, a specific spectrum of light that bounces off or through an object (Gordon, 2003: 56). Color has several properties, such as saturation, hue, and value that have numerous variations of a single color through tints, tones, and shades. Studies on color and its properties are mainly concerned with how it influences affective space dimensions, excitement, and dominance (Riley, 1996: 321; Yildirim et al., 2011: 509-524; Curcic et al. 2019: 866-877). The theory defines light, warm, and saturated colors as more arousing; they increase the apparent size of space or object, while deep, cool, dull, or muted colors have the opposite effect and appear to contract the space. Opposingly, light values, cool hues, and grayed colors are used to enhance the spaciousness of a room and increase its apparent width, length, or ceiling height. Dark values and saturated colors suggest nearness. These traits can be used to diminish the scale of a space or, in an illusory way, to shorten a room’s various dimensions. If receding colors with low contrast are applied, it will create a feeling of spaciousness, while strong color

contrasts and/or advancing colors will reduce it (Kilmer & Kilmer, 2014: 166-175; Dodsworth, 2009: 130; Love & Grimley, 2007: 78).

There is a significant research body on the impact of color on space perception. Specifically, a study on the emotional reactions to red, green, blue, and gray colors introduced in the living room states that the most recorded emotions associated for the red room were disgust and happiness, while the least stated emotions were sadness, fear, anger, and surprise; for the green room, neutral and happiness were the most stated emotions, and anger, surprise, fear, and sadness were the least stated ones; for the blue room, neutral was the most stated emotion, while the least stated emotions were anger and surprise. Neutral, disgust, and sadness were the most stated emotions for the gray room. Gender differences were not found in human emotional reactions to living rooms with different wall colors (Günes and Olgunturk, 2020: 139). Similarly, research on the investigation of the effects of colors and spatial-architectural dimension in the work environment, argues that the variations in space perception were significantly associated with the difference in color, area, and height. In this research, it is argued that neutral colors were had the most positive response in all considered factors of space perception (Savavibool and Moorapun, 2017: 357).

Correspondingly, pattern as one of the primary characteristics of surfaces, has been greatly studied because they can influence the perception through altered proportional readings of a space. Large-scale repeats with complex patterns and contrasting colors can be appealing in a large room but can create overwhelming emotions in a small room. Patterns with vertical lines can add visual height to a room with low ceilings. Conversely, patterns with horizontal lines can make a room or a piece of furniture look wider (Kilmer & Kilmer, 2014: 128). Castell et al. (2020: 50) on the other hand argue that object-based texture effects cannot be generalized to interior space perception, stating that pattern density impacts visual perception more than pattern orientation. However, despite the large academic body, it is still difficult to form a single solid framework that associates, quantifies, and defines the interaction between color and pattern with space perception. Though existing theories that analyze the impact of individual factors and their interaction with space and subsequent perceptive response are not realistic, as spatial assessment is always resulting from multiple factors; they form a solid base for future research.

METHOD

This study aims to evaluate perception and experience of interior architectural space, spatial properties, and visual weight, attempting to understand interaction of color, patterns, and surface qualities with space. In particular, it evaluates the effect of advancing and receding colors, large- and small-scale patterns, reflectiveness and refractiveness of surfaces. For the exploratory purposes of this study, the semantic differential as simple and widely used method for the approximatively quantification of emotional responses is chosen (Franz, 2006: 4). The combination of pairs of oppositional adjectives with a Likert scale are used for the three primary dimensions (pleasure, arousal, and dominance) of emotion as occurring in affective appraisals (Mehrabian & Russell, 1974 :18), and are presented in Figure 1 and Table 1 respectively. It has been argued that such a framework allows effective quantification of affective responses using introspective verbal scale setting. In addition, ratings of dominance and spatiality or openness were collected to detect possible interactions between room color and experienced room dimensions.

Table 1. Semantic differential rating categories used in the experiment

Dimension	Category	English high extreme	English low extreme
Valence	Pleasantness Harmony	Pleasant Positive	Unpleasant Negative
Arousal	Excitement Interestingness	Calming Interesting	Exciting Boring
Dominance	Obtrusiveness Gravity	Inobtrusive Light	Obtrusive Oppressive
Spatiality	Spaciousness Enclosure	Narrow Open	Spacious Enclosed

PLEASE RATE YOUR EXPERIENCE OF THE SPACE PRESENTED BELOW *

	1	2	3	4	5
1 - unpleasant; 5 - pleasant	○	○	○	○	○
1 - positive; 5 - negative	○	○	○	○	○
1 -exciting; 5 - calming	○	○	○	○	○
1 - interesting; 5 - borring	○	○	○	○	○
1 - inobtrusive; 5 - obtrusive	○	○	○	○	○
1 - light; 5 - opressive	○	○	○	○	○
1 - narrow; 5 - spaciouss	○	○	○	○	○
1 - open; 5 - enclosed	○	○	○	○	○

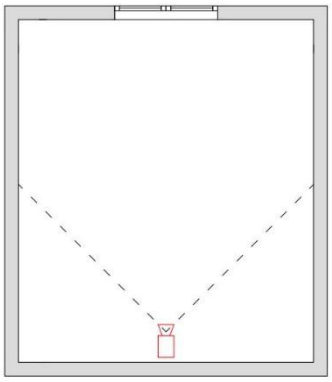


Figure 1a. Questionnaire used in survey

1b. Layout of room with camera and opening position

Research Model

The experiment is conducted using a 3D modelled virtual room. This study recruited 93 participants in total, out of whom forty-two mail and fifty-one female respondents, with average age 38.6, evaluated the presented spatial models. Presented spaces were dimensionally equal (being 4.3mx5m and height of 2.8m), with a 1.5mx2.2m opening positioned at the center of the adjacent wall. In all scenes the surface of the floor is covered with light wood parquet. The position of the camera is fixed and equal for all scenes and its height was set at the eyelevel, or to 1.6m, being accepted as the average height (Figure 1b). By treating the vertical and horizontal surface of the ceiling fully and partially with advancing or receding color, floral and geometrical pattern of larger and smaller scale a total of 27 scene variations are obtained.

93 respondents were asked to evaluate their perception on the space in four dimensions: valence, excitement, dominance, and spatiality, and eight categories: pleasantness, harmony, excitement, interestingness, obtrusiveness, gravity, spaciousness and enclosure. Using web-based questionnaire form, the survey was distributed online (e-mail and social media), together with a description of the experiment and brief instructions, by which they were introduced to the experimental activity and its general purpose. In order to obtain the most sincere reaction, the participant were asked to respond quickly and in accordance to their first impression. The survey conducted has been revised and approved by the Ethics Committee, document no.: 01-400/22, date 10/11/2022.

Different variations of the scenes were made through manipulation of vertical surfaces and different color applications. Two advancing and two receding colors were applied, on different positions. First all surfaces were painted in one color (receding or advancing), next the whole room but the ceiling stayed white, then only the wall with the opening was painted in given color, after that ceiling and wall with the opening were painted and finally only two side walls were painted. After the application of color, pattern was used - two floral and three geometrical. At the end, walls were treated with mirror and transparent material. Total of 27 different scenes were created.

FINDINGS

The following tables present the high values of perception evaluation by participants in the indicated dimensions and categories.

Colors

Receiding	VALENCE		AROUSAL		DOMINANCE		SPATIALITY	
	PLEASINGNESS	HARMONY	EXCITEMENT	INTERESTINGNESS	OBTRUSIVENESS	GRAVITY	SPACIOUSNESS	ENCLOSURE
	26.88% neutral	23.65% positive	25.80% neutral	25.80% neutral	30.10% inobtrusive	23.65% light	27.95% neutral	25.80% enclosed
	41.93% unpleasant	26.88% negative	30.10% exciting	29.03% borring	37.63% inobtrusive	27.95% neutral	37.63% neutral	24.73% neutral
Advancing								
	51.61% unpleasant	31.18% negative	45.16% exciting	35.48% borring	48.38% obtrusive	52.68% heavy	29.03% narrow	47.31% enclosed
	43.01% unpleasant	25.80% negative	36.55% exciting	26.88% borring	26.88% obtrusive	36.55% neutralno	30.10% narrow	26.88% enclosed

Figure 2. Survey results of the application of colors on all walls

Colors

Receiding	VALENCE		AROUSAL		DOMINANCE		SPATIALITY	
	PLEASINGNESS	HARMONY	EXCITEMENT	INTERESTINGNESS	OBTRUSIVENESS	GRAVITY	SPACIOUSNESS	ENCLOSURE
	37.63% neutral	37.63% neutral	29.03% neutral	35.48% neutral	34.40% neutral	26.88% neutral	27.95% spaciouss	27.95% neutral
	44.08% neutral	45.16% neutral	45.16% neutral	44.08% neutral	31.18% neutral	44.08% neutral	37.63% neutral	41.93% neutral
Advancing								
	32.25% neutral	36.55% neutral	34.40% exciting	33.33% neutral	32.25% neutral	29.03% neutral	36.55% narrow	31.18% neutral
	33.33% neutral	39.78% neutral	35.48% neutral	30.10% neutralno	37.63% neutral	41.93% neutral	34.40% neutral	35.48% neutral

Figure 3. Survey results when ceiling is white

Colors

Receiding	VALENCE		AROUSAL		DOMINANCE		SPATIALITY	
	PLEASINGNESS	HARMONY	EXCITEMENT	INTERESTINGNESS	OBTRUSIVENESS	GRAVITY	SPACIOUSNESS	ENCLOSURE
	25.80% pleasant	37.63% neutral	29.03% neutral	30.10% neutral	32.25% neutral	30.10% neutral	27.95% neutral	32.25% neutral
	36.55% neutral	31.18% neutral	32.25% neutral	27.95% neutral	27.95% neutral	31.18% light	32.25% spaciouss	27.95% open
Advancing								
	39.78% neutral	36.55% neutral	37.63% neutral	33.33% neutral	32.25% neutral	33.33% light	32.25% neutral	30.10% neutral
	32.25% neutral	32.25% neutral	32.25% neutral	31.18% neutral	32.25% neutral	33.33% light	34.40% neutral	33.33% open

Figure 4. Survey results when color is applied only on the back wall

Colors

Receiding	VALENCE		AROUSAL		DOMINANCE		SPATIALITY	
	PLEASINGNESS	HARMONY	EXCITEMENT	INTERESTINGNESS	OBTRUSIVENESS	GRAVITY	SPACIOUSNESS	ENCLOSURE
	36.55% neutral	30.10% neutral	40.86% neutral	32.25% neutral	38.70% neutral	32.25% neutral	35.48% neutral	33.33% neutral
	31.18% neutral	33.33% neutral	37.63% neutral	47.31% neutral	44.08% neutral	36.55% neutral	32.25% neutral	30.10% neutral
Advancing								
	32.25% neutral	36.55% neutral	41.93% neutral	35.48% neutral	35.48% neutral	35.48% neutral	40.86% neutral	41.93% neutral
	29.03% neutral	31.18% neutral	43.01% neutral	32.25% neutral	39.78% neutral	38.70% neutral	32.25% neutral	34.40% neutral

Figure 5. Survey results when same color is applied both on the back wall and on the ceiling

Colors

Receiding	VALENCE		AROUSAL		DOMINANCE		SPATIALITY	
	PLEASINGNESS	HARMONY	EXCITEMENT	INTERESTINGNESS	OBTRUSIVENESS	GRAVITY	SPACIOUSNESS	ENCLOSURE
	32.25% neutral	32.25% neutral	35.48% neutral	32.25% neutral	32.25% neutral	27.95% light	35.48% neutral	29.03% neutral
	31.18% neutral	34.40% neutral	35.48% neutral	30.10% neutral	37.63% neutral	36.55% neutral	41.93% neutral	32.25% neutral
Advancing								
	33.33% neutral	31.18% neutral	41.93% neutral	37.63% neutral	27.95% neutral	31.18% light	31.18% neutral	35.48% neutral
	27.95% neutral	35.48% neutral	36.55% neutral	27.95% neutral	29.03% neutral	33.33% neutral	31.18% neutral	33.33% neutral

Figure 6. Survey results when color is applied on opposing walls

Pattern

	VALENCE		AROUSAL		DOMINANCE		SPATIALITY	
	PLEASINGNESS	HARMONY	EXCITEMENT	INTERESTINGNESS	OBTRUSIVENESS	GRAVITY	SPACIOUSNESS	ENCLOSURE
	26.88% pleasant	23.65% positive	27.95% neutral	34.40% interesting	24.73% obtrusive	26.88% light	31.18% neutral	30.10% neutral
	22.58% unpleasant	24.73% positive	26.88% neutral	29.03% interesting	27.95% neutral	29.03% neutral	34.40% neutral	29.03% neutral
	38.70% pleasant	33.33% positive	35.48% neutral	39.78% interesting	31.18% inobtrusive	35.48% light	30.10% neutral	34.40% open
	34.40% unpleasant	29.03% neutral	31.18% exciting	27.95% interesting	30.10% obtrusive	32.25% neutral	37.63% neutral	38.70% neutral
	26.88% neutral	35.48% neutral	30.10% neutral	33.33% neutral	35.48% neutral	34.40% neutral	40.86% neutral	43.01% neutral

Figure 7. Survey results when pattern is used

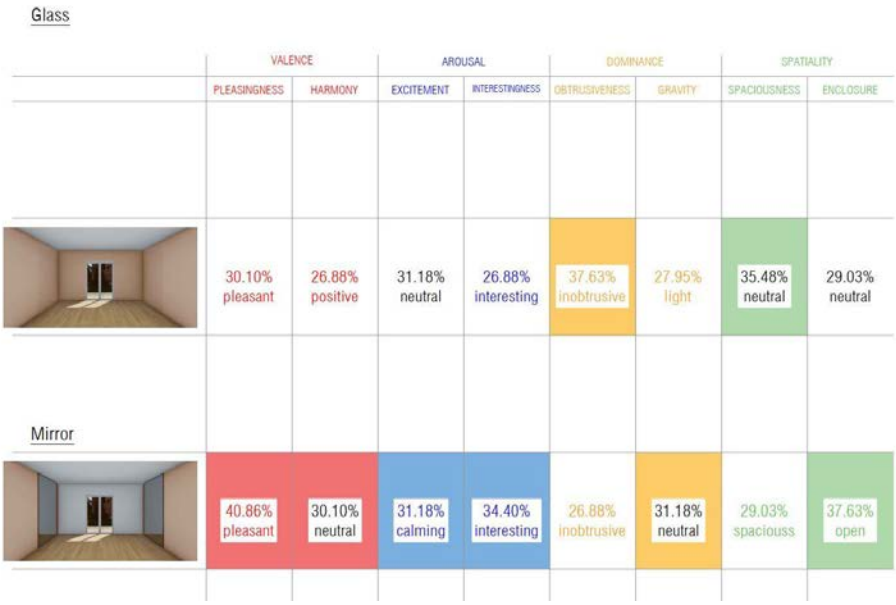


Figure 8. Survey results when glass and mirror are introduced to the room

A chart of complete results of each model is presented as follows:

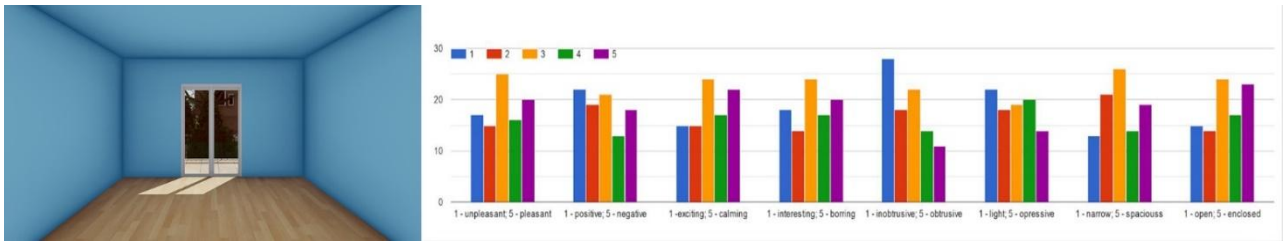


Figure 9. Survey results on question 1

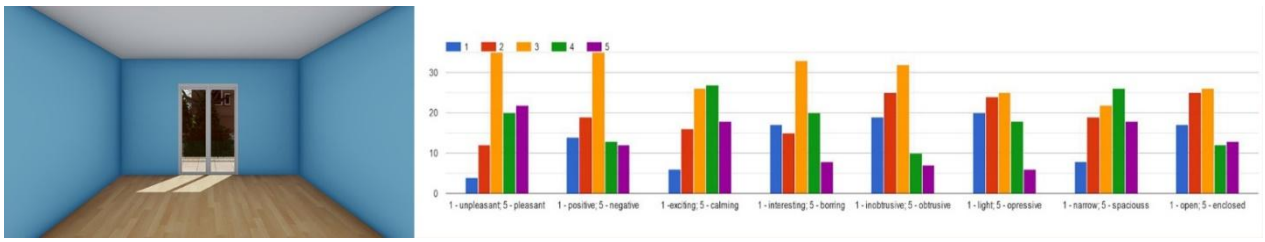


Figure 10. Survey results on question 2

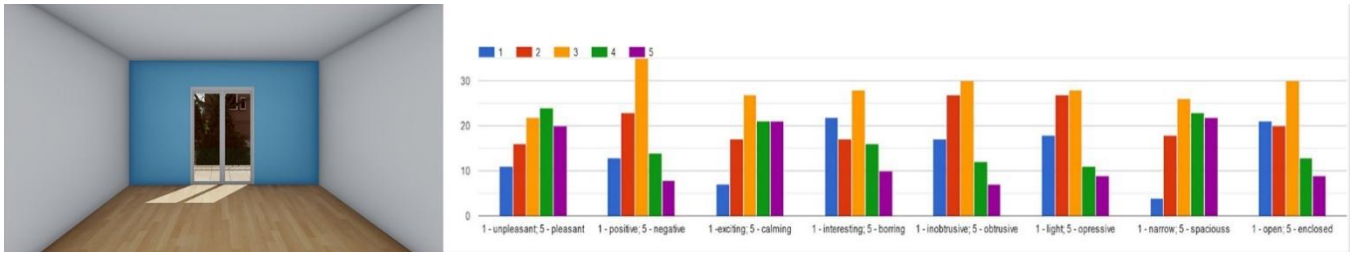


Figure 11. Survey results on question 3

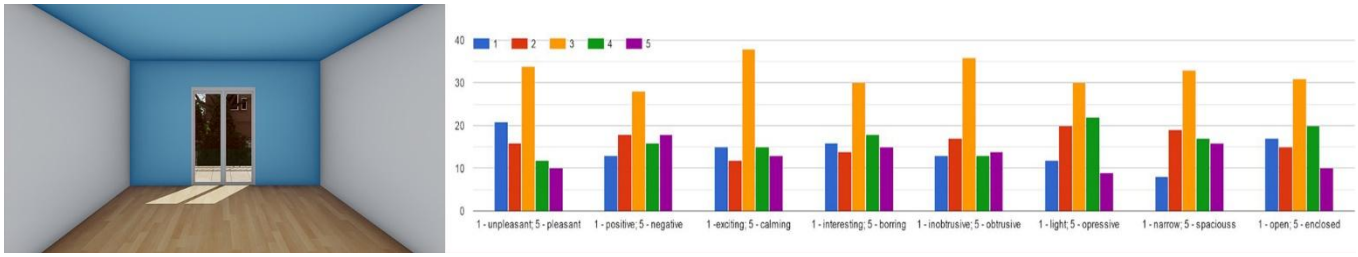


Figure 12. Survey results on question 4

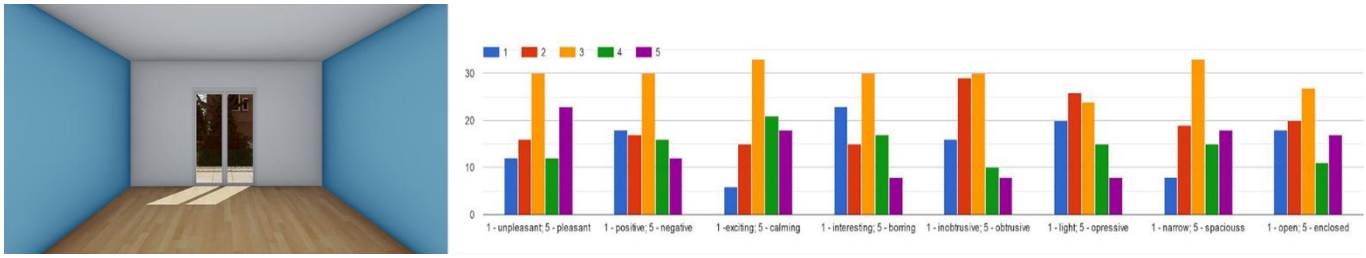


Figure 13. Survey results on question 5

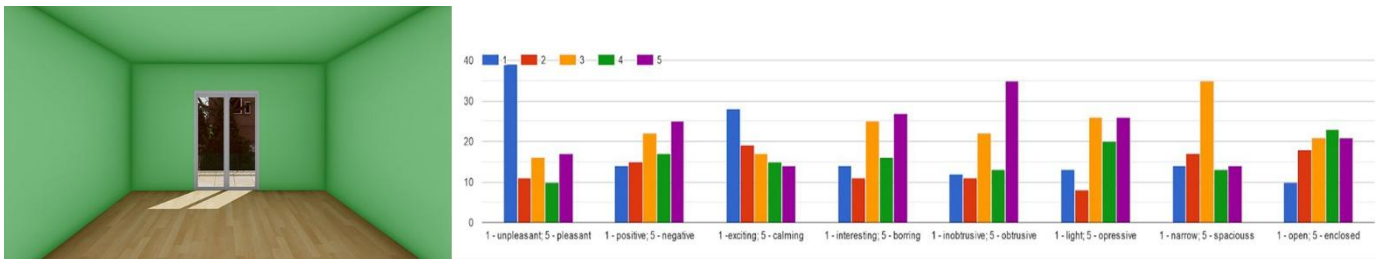


Figure 14. Survey results on question 6

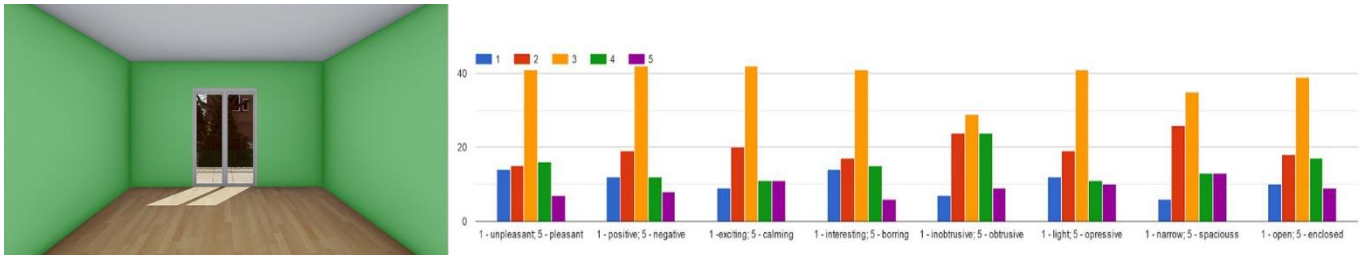


Figure 15. Survey results on question 7

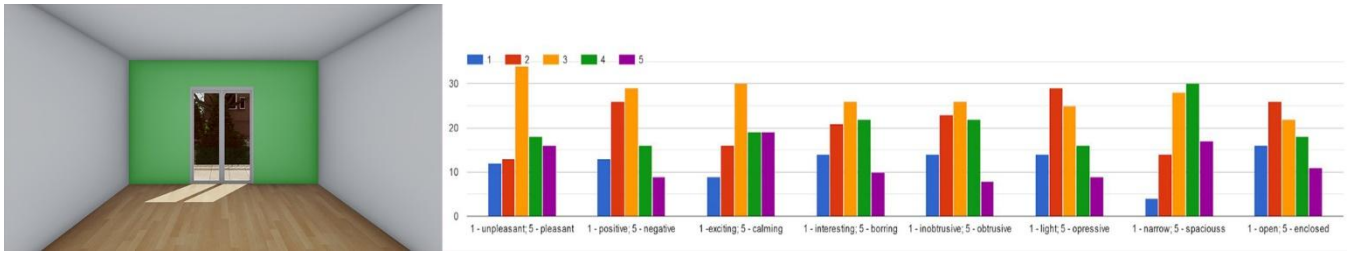


Figure 16. Survey results on question 8

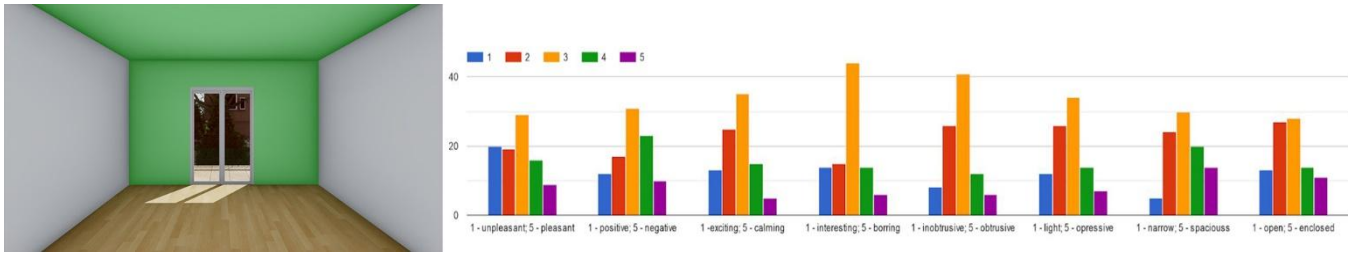


Figure 17. Survey results on question 9

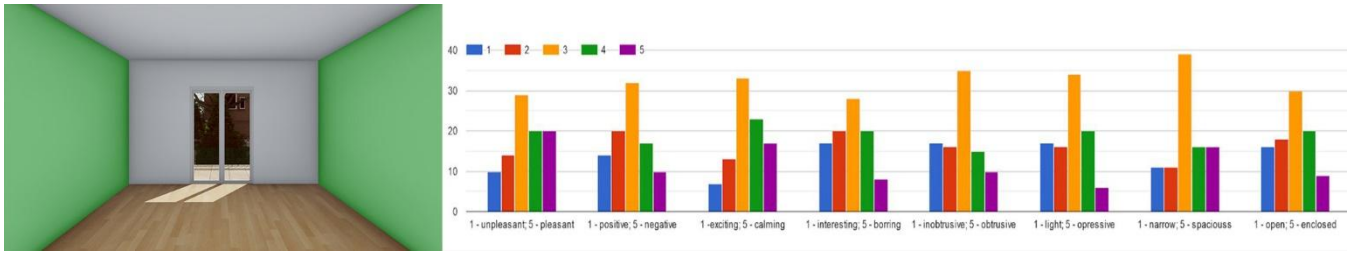


Figure 18. Survey results on question 10

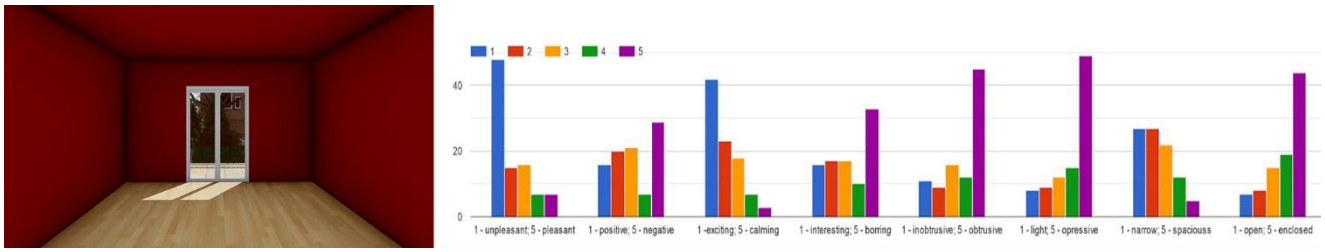


Figure 19. Survey results on question 11

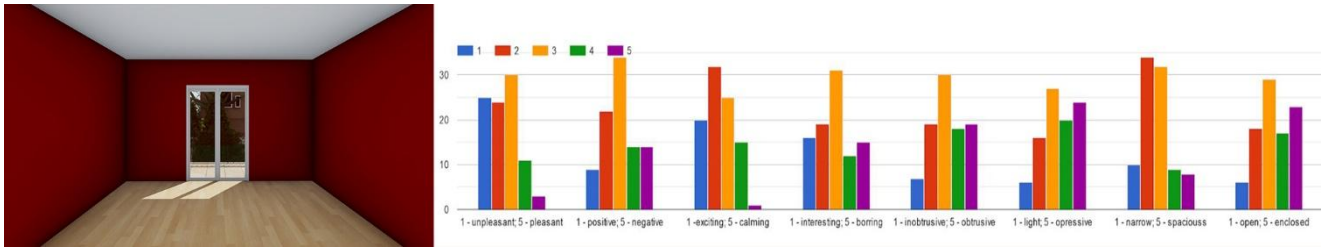


Figure 20. Survey results on question 12

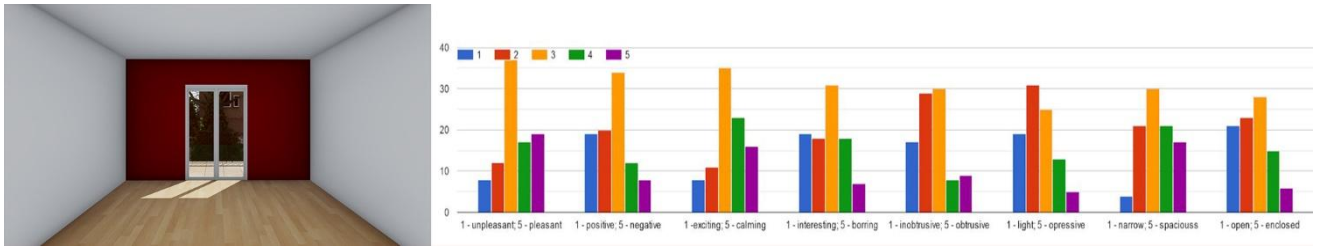


Figure 21. Survey results on question 13

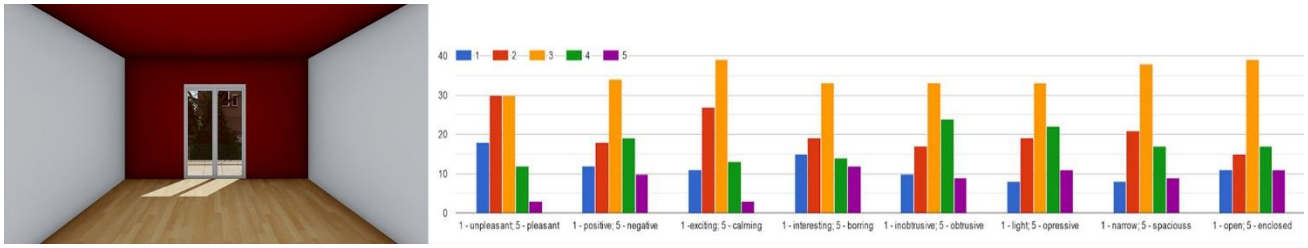


Figure 22. Survey results on question 14

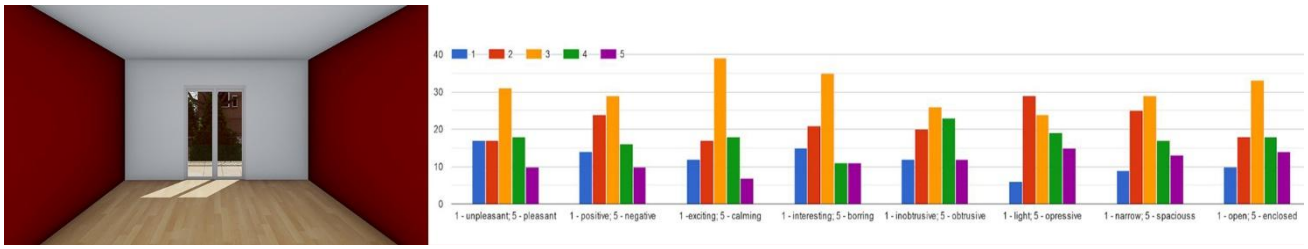


Figure 23. Survey results on question 15

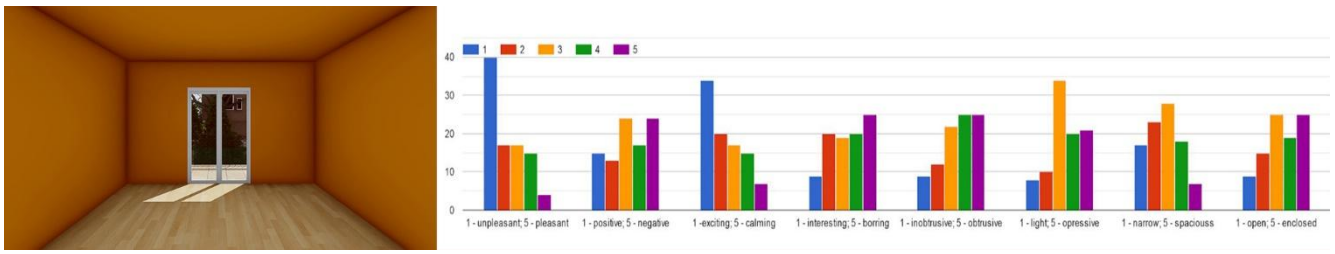
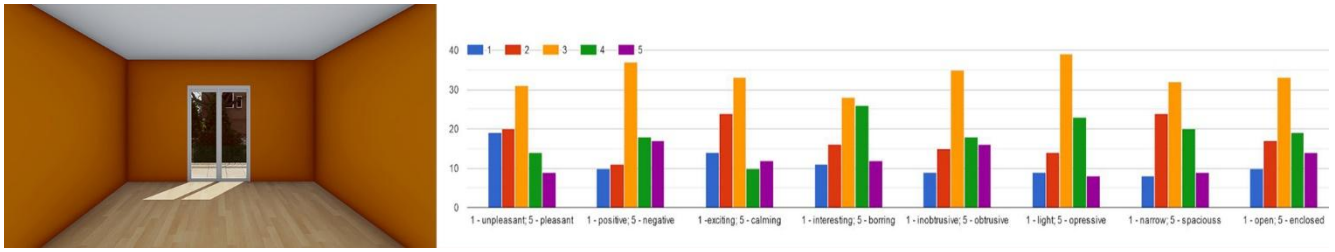


Figure 24. Survey results on question 16



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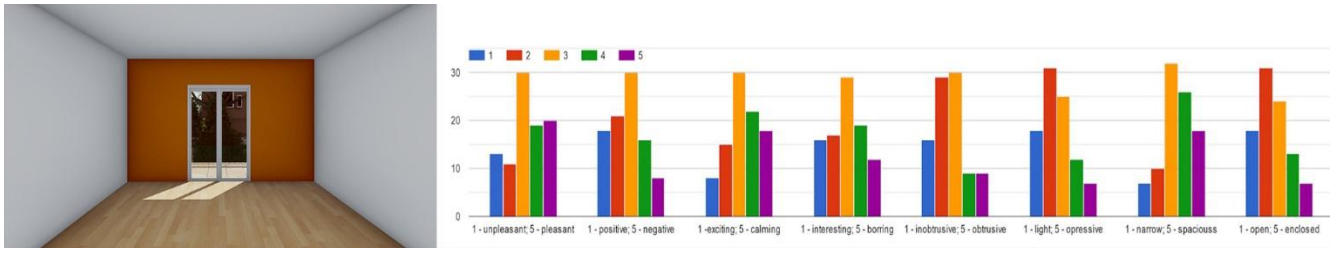
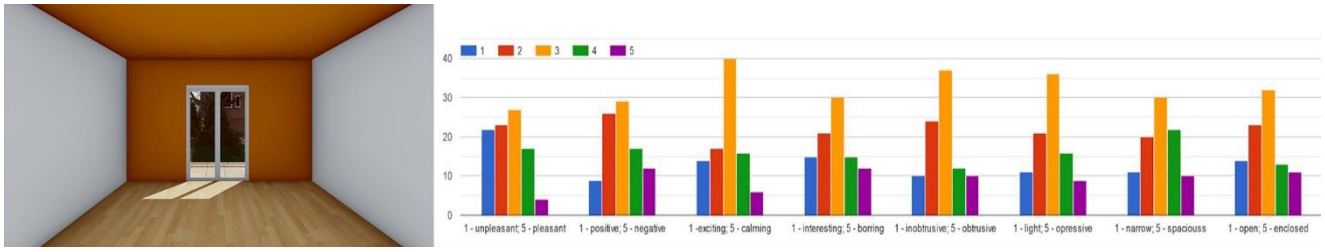


Figure 26. Survey results on question 18



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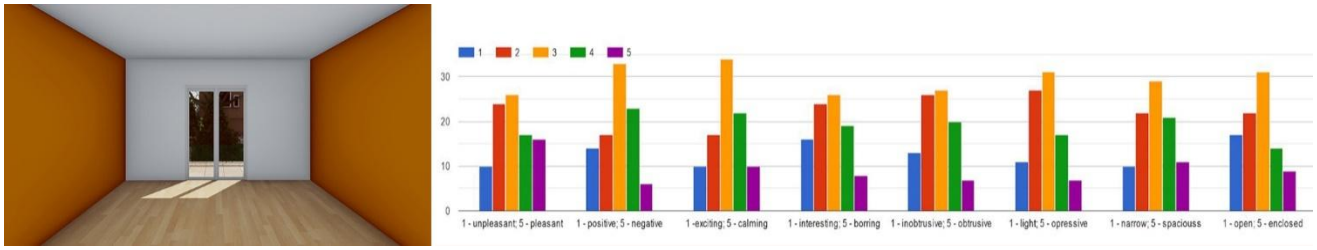

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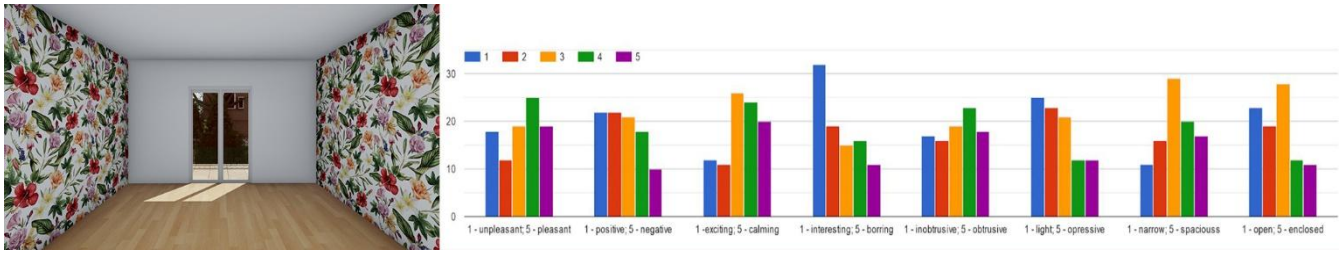

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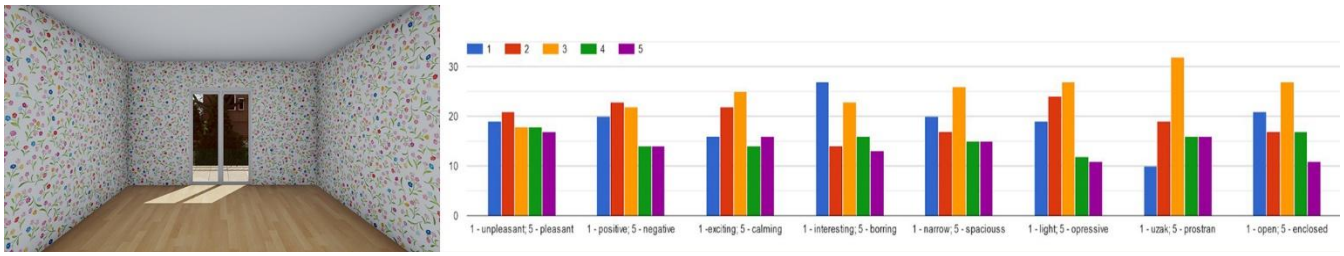

Figure 30. Survey results on question 22

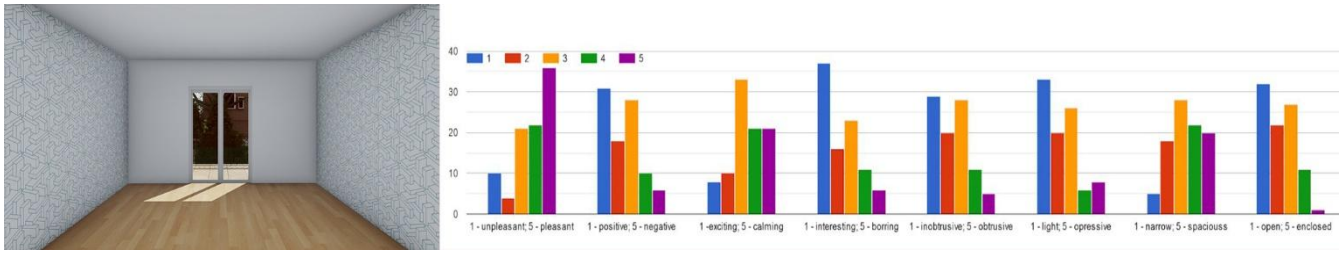

Figure 31. Survey results on question 23

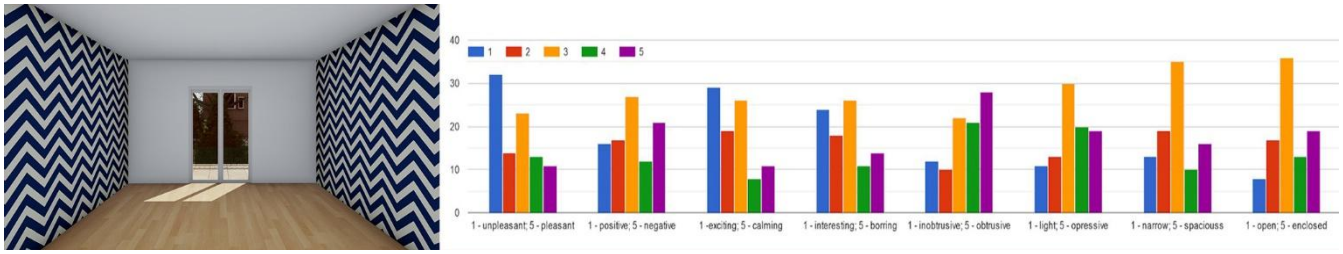

Figure 32. Survey results on question 24

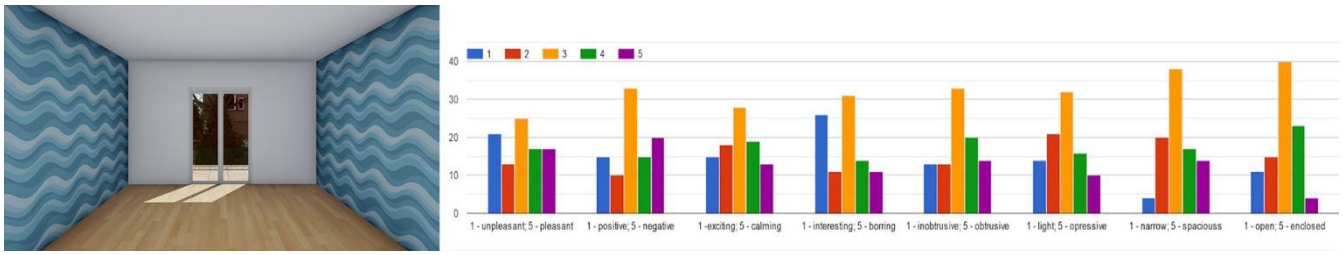

Figure 33. Survey results on question 25

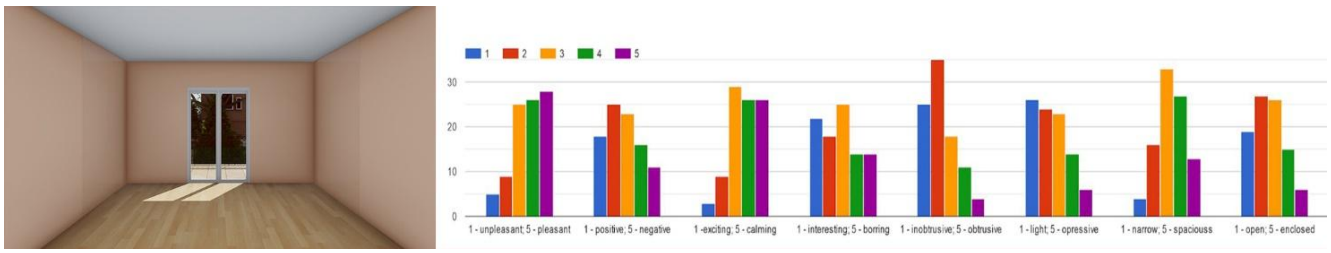

Figure 34. Survey results on question 26

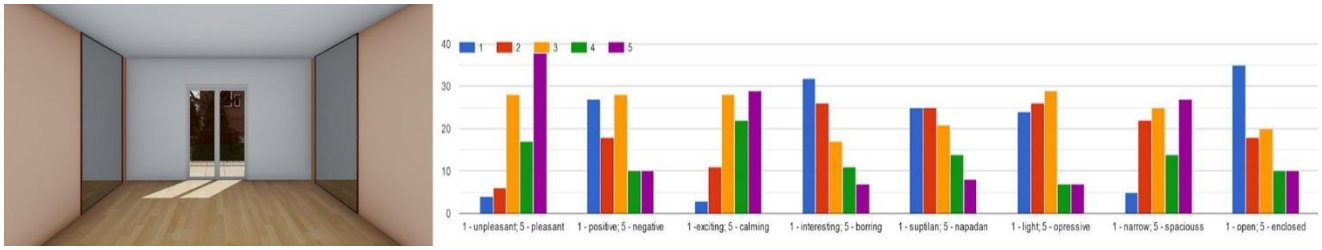

Figure 35. Survey results on question 27

In total 93 participants contributed to the experiment of this exploratory study, which aims to quantify the perception and the relationship between the experience of architectural indoor space with spatial dimensions and selected architectural elements. The experiment confirms that the application of color in interiors has a great impact on how the observers perceive space, significantly affecting the ratings in all the 4 dimensions evaluated.

The analysis presents that in the model where all surfaces are treated with receding colors, most of the participants' responses were neutral in regards to the evaluation and perception of pleasantness, dominance and spatiality, while they perceive it as highly harmonious and unobtrusive. The model with dominant advancing color was perceived as unpleasant with a high level of arousal, dominant and enclosed. Namely more than 51% of respondents perceived these colors as unpleasant, 45% rated them as exciting, 48% as obtrusive and 47% as enclosed. When colors were not applied on all the walls, most of the results were neutral so it can be said that it had no significant impact on visual perception. Regarding correlations between advancing and receding colors, in terms of spatiality and dominance, the opposite tendencies have been

recorded. If a space was perceived as obtrusive and enclosed when using advancing colors, results are showing that when receding colors are used, the same space seems to be more open and lighter.

Models with vertical surfaces that were treated with patterns have been perceived as more interesting than the others, with the mean of 32.7%. Interestingly, a model with a geometrical, large scale, highly contrasting linear pattern was defined as the least interesting but exciting, obtrusive, and unpleasant. Opposingly respondents perceived the space with less contrasting linear geometrical patterns, pleasant and unobtrusive. Remarkably, it has been noted that models which were treated with floral patterns were perceived as if they don't make the space more pleasant than the geometrical pattern. Eventually, 22.5% of the respondents found floral patterns to be pleasant compared to 38.7% that responded positively in the same category for the geometrical pattern. Regarding spatiality, application of pattern had no significant effect on visual perception of the space.

As for the use of highly reflective treatment of surfaces or mirrors in interior space, most respondents perceived the model to be spacious (29.3%) and open (37.6%). Furthermore, the results show the impact of mirrors in pleasingness and excitement, as 40.8% of respondents found the space to be pleasant and 31.18% rated it as calming. When it comes to the use of highly refractive or transparent materials, usage of glass in the interior was evaluated positively in all dimensions and categories presented.

CONCLUSION

The fundamental challenge in understanding how interior space is perceived, is the difficulty of systematically recording the impact of spatial features on the users. There is a very small number of empirical studies, and it is acknowledged that dealing with it through quantitative analysis, is not sufficiently flexible to apply it to a variety of spaces, nor is it sufficiently comprehensive to capture all the relevant features that might be found in a space. The aim is not only to attempt to quantify the correlation between the elements and positive response, but also to provide useful information on the influence of surface characteristics on visual perception, which could potentially be used to improve indoor environment quality. The study confirms that virtual reality simulations are an extremely useful and effective tool for basic architectural research that enables the application of novel empirical methods in researches, thus resulting in faster acquisition of findings. In broadest terms, the results of the study also confirm that aspects of perception and spatial experience are analytically investigable and have detectable correspondents in the physical environment, as well as that selected spatial properties greatly influence spatial perception. Among the investigated properties, color selection has demonstrated to be the primary factor impacting perception, particularly valence and spatiality, while the size of pattern was related mostly with spatial proportions and affected the perception of dominance and spatiality. Additionally, patterns with strong color contrasts and angular geometry are perceived more as unpleasant and obtrusive, in comparison to small scale patterns, as well as patterns with lower color contrast. Interestingly, there were no significant differences in perception, related to selective coloring of space surfaces in all categories evaluated. It must be noted that the virtual conditions of the modeled environment may have impacted results to a certain level. Also, to be able to obtain more solid conclusions to the raised questions, the research should be expanded in the future, by associating responses not only to different color typology, but also to tones and tints, and to the influence of natural and artificial light, and other elements of interior design compositions, such as furniture, proportions, sizes, etc.

However, the study confirms that the systematic investigation of correlation between physical properties of indoor spaces and the evaluation of their affective qualities is possible. It also acknowledges that regardless of the limitations, they have the potential to result in qualified predictions for design. Such investigations are beneficial not only for professionals but also for the users, as reliable quantification methods for experiential qualities can help create spatial compositions of high order, and thus greater visual and spatial quality. Furthermore, the study contributes to the research body associated with environmental perception, as well as emotional and cognitive spatial perception. Continuation of studies along these lines, expansion and variables, may contribute to developing a more apprehensive methodological framework, which may lead designers in responding more appropriately to perceptual, and therefore comfort level and needs in general. Ultimately such a framework would be useful for the increase in the level of conformity of spatial compositions and quality of indoor environments.

Authors' Contributions

All authors contributed equally to the study.

Competing Interests

There is no potential conflict of interest.

Ethics Committee Declaration

Based on the Statute of the Higher Education Institution International Burch University, and pursuant to Article 169 of the Law on Administrative Procedure of the Federation Bosnia and Herzegovina ("FB&H Official Gazette", No. 2/98, 48/99), the Ethics Committee certifies that the research manuscript *Perception and evaluation of interior space: experimental study on color and pattern* has been reviewed and approved by the University's Ethics Committee. (Ref. No.: 01-400/22 Sarajevo, 10/11/2022).

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Figure References

Table 1: Franz, G. (2006). *Space, color, and perceived qualities of indoor environments.* Max Planck Institute for Biological Cybernetics.

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