INTERIOR MORPHOLOGY AND THE RESPONSE OF SPACE PERCEIVERS

Moamen Nasser Abdallah *, Shaimaa Mohamed Kamel and Haitham Abdelsalam Mohamed

Department of Architecture, Faculty of Engineering, Ain Shams University, Cairo, Egypt

*Corresponding author E-mail: moamen_nasser@eng.asu.edu.eg

Abstract

Humans spend most of their time indoors as Studies found that Humans spend almost 90% of their time indoors. This means that space perceivers may be directly subjected to the interior design of these spaces and thus the interior design elements including the interior morphology may have an impact on the space perceivers. One of the most essential elements of interior design space morphology is contour. Contour studies have been argued for more than a century as researchers approached the contour preference with variable methods reaching different reasons of contour typology preference. The aim of this paper is to study and investigate the findings in contour preference studies in order to provide a clear understanding of the interior morphology and it's impact on the response of the space perceivers. The methodology used is a comparative analysis method that investigates the past contour preference studies.

The results found that the response of perceivers was impacted by contour typologies & interior morphology. There is always a preference for curvilinear contours compared to other typologies. Researchers argued that this preference for curvilinear contours may be due to the fact the perceivers found them more pleasing than other typologies. In Conclusion, It was found that past studies didn't highlight enough the rectilinear contours. The interior settings contour preference studies lacked the investigation of contour quantity & repetition in addition to the function of space. This notion requires further investigation while taking into consideration all contour typologies and highlighting contour quantity and space function.

Keywords: Interior morphology, Contour typology, Contour preference, Curvilinear Contour, Space Perceiver

1. INTRODUCTION

The interior setting in which perceivers interact is formed through multiple aspects. The interior morphology is considered to be a main aspect of the interior space design. From an architectural point of view, morphology is defined as the shapes and forms of buildings and architectural plans [1]. These shapes and forms create the interior setting. Contour is the main ingredient of forms thus space design. Le Corbusier considered the contours to be the most important feature in architecture and interior design that enables designers to create the interior settings [2].

Contours are lines or edges that form the surfaces, masses and interior envelopes. Researchers has been studying the contour typologies and the response of their perceivers. The contour typologies were mainly defined by researchers as curvilinear, angular and rectilinear straight. The contour preference studies found that the contour typologies have an impact on the response of their perceivers.

Therefore, researchers highlighted contour preference in order to understand the response of the perceivers. This paper will investigate research papers and findings related to contour, contour preference and interior setting contour preference.

2. OBJECTIVE

The objective of the paper is to give a clear understanding of the response of space perceivers when subjected to interior space morphologies. It will reach this aim through analyzing the basic design element (i.e. Contour) and highlight the response of it's perceivers. This will provide a guide for architects and interior designers that enables them to understand the impact of contour on the space perceivers' response.

3. METHODOLOGY

A comparative analysis was carried out between studies and findings in contour, contour preference and interior setting contour preference published in 20th century and 21st century.

4. CONTOUR PREFERENCE

Contours have been studied by researchers for over a century. These contours form almost everything surrounding humans from objects to built interior environments. Humans spend almost 90% of their time surrounded by built interior environments [3]. Thus, it is essential to investigate contour studies in order to understand the response of their perceivers and help in understanding their behavior in built interior environments. This part of the paper investigates the contour preference experiments. It will also demonstrate both early and modern findings in this field.

More focused studies in recent time began to peruse the contour preference. In an attempt to investigate the past findings and experiment the contour preference and the factors that may impact the observers.

Upon studying different geometric shapes, Larson et. al. [4] found that human behavior is associated with the shape of contours. The authors studied the human reaction to both curved and angular contours and recorded the response. Larson et. al. [4] discovered that contours with converging angles (i.e. angular) gave anger and threat feelings to participants unlike curved contours that depicted feelings of happiness and pleasantness in the participants' responses which was resembled the discoveries of Aronoff [5].

Bar & Neta [6] experimented the contour preference through using real life stimuli. The researchers used same objects but with different edge or contour typology in addition to combining both contour typologies in control objects. Watches with round and sharp corners or a guitar with round contours or sharp ones were used in the experiment. The reason behind using daily items with different angles was to eliminate the idea of meaning implications positive or negative. In addition to the objects used the researchers also included meaningless patterns in order to assist the investigation and avoid a semantic meanings and typicality as shown in figure 1.

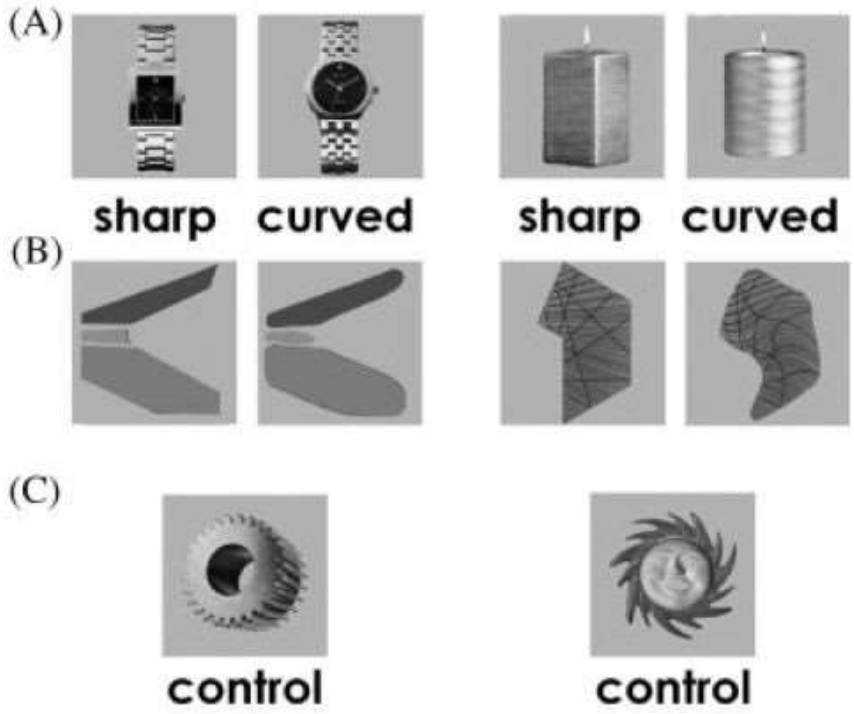

Figure (1): (A) Pair of real objects with sharp and curved contours. (B) Pairs of novel patterns with sharp and curved contours. (C) Real objects with sharp and curved contours (Control Objects) [6]

The percentage of Liking in first method was calculated as an indicator for preference. Curved contour objects were preferred more than control objects. While sharp contour objects were less liked than control objects by participants. Which also was concluded from the novel patterns.

The second method detected high activation in both right and left amygdala which detects the perception of threat in angular contour objects than curved contour objects as seen in figure 2.

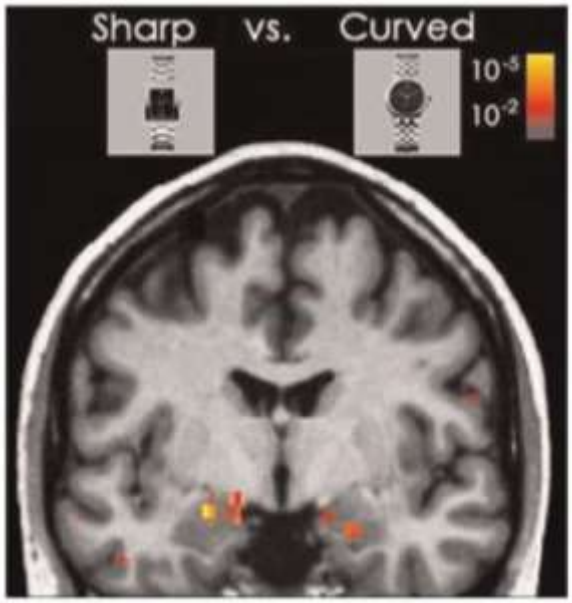

Figure (2): Bilateral (Left & Right) amygdala activation was increased for sharp contour stimuli compared with the same stimuli when they have curved contours instead. [6]

Silvia & Barona [7] argued that some objects used by Bar & Neta [6] were typical elements like sofas or watches which could depict typicality. As these objects are usually with curved corners or contours. Which in return could impact the observers and influence their liking. Garner [8] believed that symmetry is more preferred than asymmetry as it contains less information to process. Silvia & Barona [7] discussed that the preference of a round cornered watch compared to a sharp corned watch could be due to a symmetry issue as Circles have more symmetry axes than rectangles.

The researchers investigated the contours while taking into considerations the issues of typicality of objects and their symmetry which was not highlighted by Bar & Neta [6]. Circles and hexagons were both used by Silvia & Barona [7] as they were symmetric in their vertical, horizontal and diagonal axes. The researchers controlled symmetry, typicality and balance see figure 3.

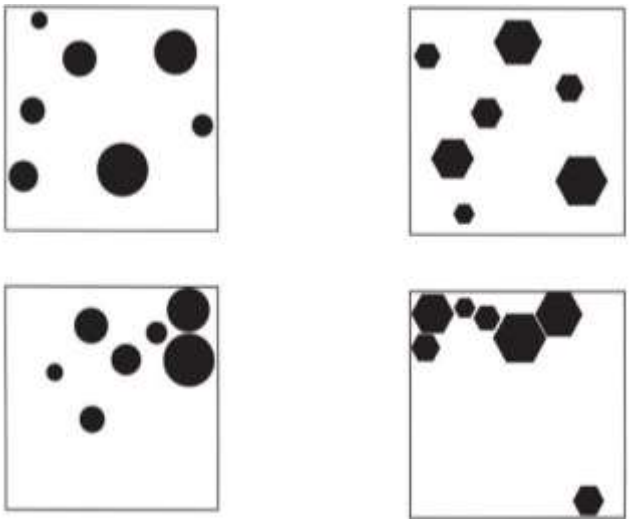

Figure (3): Shows groups of circles and hexagons used during the experiment by Silvia & Barona [7].

The researchers measured the pleasantness of stimuli as an indicator of preference response by asking participants this question "How pleasing is this picture?" (1=not at all, 9=very pleasing). Participants found that angular hexagons are less pleasing than circles. Which was also concluded by Bar & Neta [6] despite the fact that the control of symmetry and typicality was absent.

The concept of typicality that was eliminated in the some of the test stimuli of both Bar & Neta [6] and Silvia & Barona [7] was further discussed by Carbon [9]. The author discussed the concept of familiarity (i.e. typicality) and investigated it's impact on perceivers. Participants were shown different car designs and style of different eras with both curved and angular contours. Carbon [9] found that the perceivers or participants preferred curved contours over angular contours only when the contour typology was a trend in the car designs at a specific era. This notion strengthens the concept of typicality and it's impact on contour preference. Bar & Neta [6] used sets of meaningless patterns to avoid any forms of familiarity or typicality while Silvia & Barona [7] used groups of circles and hexagons to avoid any semantic meanings or familiarity to participant's daily life routine.

Leder et. al. [10] investigated the contour preference and the emotional valence of objects. The authors used in their experiment 20 sets of real objects with contour manipulation (curved and angular contours) as seen in figure 4. It was discovered that curved versions of objects with positive or neutral valence were more preferred than their angular versions. When objects were associated with negative valence, there was no clear contour preference.

This notion depicts that curved contours are more associated with positive emotions unlike angular contours that gives threat detection to participants. The semantic meaning plays an important role in contour preference as threatening objects were not preferred in both curved and angular versions. The discovery by Leder et. al. [10] could conclude that objects with familiarity undergo emotional association when subjected to participants. Also, Positive valence is associated with curved contours compared to angular threatening contours. Thus, it is essential in studying contours to use stimuli with no semantic meaning and avoid familiarity in order to give an accurate reading of the participants' responses.

Figure (4): Shows a sample of real objects with both curved and angular contours used in the experiment by Leder et. al. [10]

Munar et. al. [11] investigated contour preference through 36 set of real life objects with both curved and angular contours. The stimuli also used objects with no semantic meanings to avoid any association. The authors presented these stimuli and asked participants to rate their approach or avoidance decision when subjected to them. The results showed that objects or stimuli with curved contours showed more approach decisions in contract to angular contoured objects or stimuli. The authors concluded that curved contours were preferred more than angular contours.

Studies began to identify and take into consideration the term of familiarity and semantic meanings. Bertamini et. al. [12] experimented the contour preference and complexity through measuring sets of complex closed shapes ,as seen in figure 5, of both curved and angular contours on a liking sake (Zero dislike to 100 like). The results showed a preference for curved contours compared to angular contours. Curved contours were judged more complex than angular ones. The researchers also experimented simple shapes of contours but added a third contour typology (Straight contour) which has not been highlighted before. Bertamini et. al. [12] discovered that the preference of both angular and straight contours was not significant as participants showed low preference for both angular and straight contours compared to curved contours.

Cotter et.al. [13] investigated the pleasantness and interest of contours. The researchers investigated contours using stimuli from past experiments.

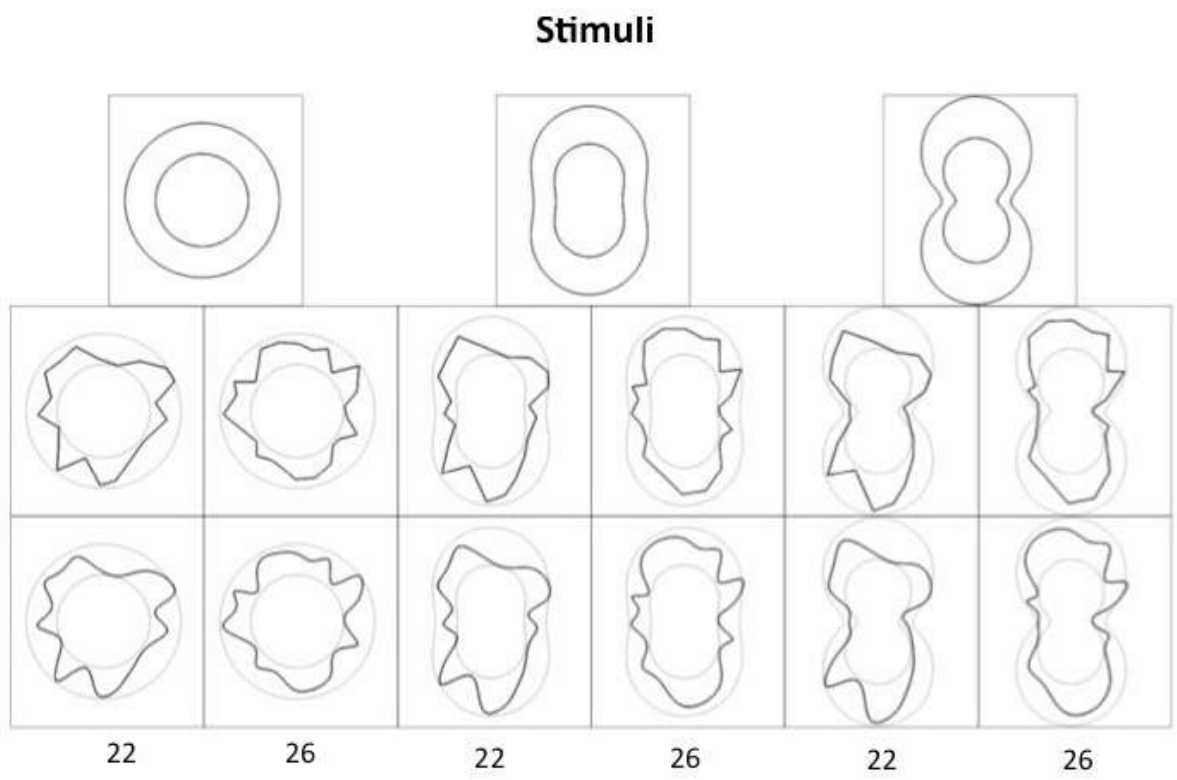

Figure (5): Depicting the stimuli of complex curved & angular closed contours [12]

They recorded the pleasantness and interest ratings of simple circles and hexagons sets used by Silvia & Barona [7] and complex closed shapes (curved and angular) used by Bertamini et. al. [12]. Cotter et.al. [13] concluded that there was a preference for curved contours in both sets through the pleasantness ratings. It was also found that the interest rating was higher in angular contours in both sets. The researchers argued that this interest in angular contours could be due to the sharp angles compared to curved contours.

The response of contour perceivers was found to be more for curved contours compared to angular contours. This discovery was seen in simple drawn shapes, simple lines or sceneries perceived, daily items and objects, novel patterns, symmetric shapes and irregular complex shapes. This notion indicates that for shapes perceived the perceivers will always respond by preferring curved contours compared to irregular contours. As for the built environment in which humans spend 90% of their time, would the space perceivers respond the same? The next part will investigate the interior morphology contours and the response of the space perceivers.

5. INTERIOR SETTING CONTOUR PREFERENCE

Previous studies in contour preference focused on contours only. These studies found that there was a preference for curvilinear contours compared to other typologies. In order to understand these response of space perceivers in built environments, it is essential to also study and investigated the findings in interior setting contour

preference. This part will investigate two approaches in this field of study. The interior contour preference will be demonstrated through an Emotional and a Neuroscientific approach.

5.1 EMOTIONAL MEASUREMENT APPROACH

Dazkir & Read [14] investigated the contours in interior environments. The researchers also highlighted the furniture forms and the response of perceivers.

The researchers experimented two layouts with two settings (curved and rectilinear). The stimuli used were rendered gray scale images (see figure 5) that were presented to participants on computer screens. According to Scherer [15] Emotions have five components: behavioral, physiological, expressional, cognitive and feeling components. The researchers measured the feeling component of aesthetic emotions in order to deduce the contour preference. This emotional measurement was based on the circumplex of emotions proposed by Russell [16].

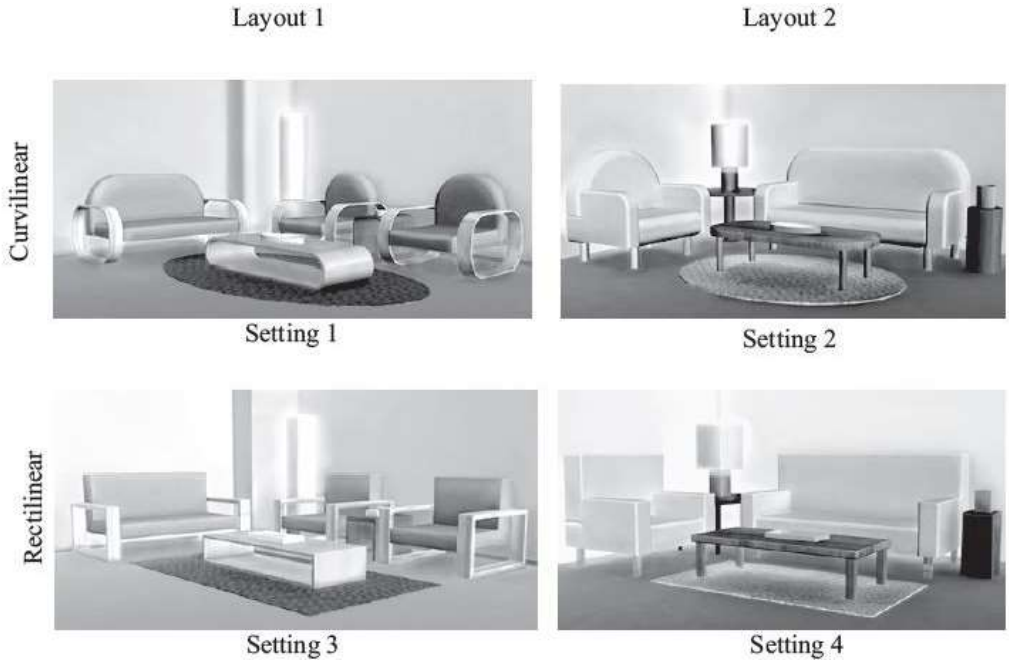

Figure (5): Depicts gray scale visual stimuli composing of curvilinear and rectilinear settings for two layouts contours [14]

The circumplex of emotions indicates that any emotion is the resultant of only two emotions: Pleasure & Arousal. For example calmness is the resultant of low level arousal and high level pleasure.Dazkir & Read [14] adopted semantic differential measures (9 point scale) of both pleasure and arousal. The pleasure was averaged from six responses (Annoyed/Pleased, Unhappy/Happy, Bored/Relaxed, Unsatisfied/ Satisfied, Melancholic/Contented and despairing/Hopeful.) while arousal was averaged from six responses (Unaroused/Aroused, Calm/Excited, Sluggish/Frenzied, Dull/

Jittery, Sleepy/Wide-awake and Relaxed/Stimulated). Besides measuring the feeling component the researchers also measured the approach desire of the participants to the presented stimuli settings. The approach was measured through sets of questions and answering response options. "How much time would you like to spend in this room?", "Once in this room, how much would you enjoy exploring around?" and "To what extent does this place make you feel friendly and talkative to a stranger who happens to be near you?" were asked to participants and would have to choose from a few responses ranging from not at all to a few hours (for question 1) or very much (for question 2).

The researchers discovered that curvilinear settings provoked pleasant-unarousing emotions such as (feeling relaxed, peacefulness, calmness) compared to rectilinear settings. Thus they concluded that curvilinear settings are more pleasing than rectilinear settings and therefore has more preference than the later. Curvilinear settings were more desired to approach than rectilinear settings.

Another attempt in studying the emotional reaction of perceivers to contours can be seen in the work of Van Oel and Van den Berkhof [17]. The authors studied the pleasing component of emotions while participants were subjects to interior built environment of airports passenger areas. Unlike Dazkir & Read [14] who studied the contour preference through grey scale stimuli, Van Oel and Van den Berkhof [17] used stimuli with no isolations. The stimuli included: Contour typology, colored themes, lighting themes, materials, people, signage and greeneries as seen in figure 6 .The authors were investigating the contour preference without excluding other elements in an attempt to reach more accurate results.

Figure (6): Depicts passenger area stimuli composing of curvilinear and rectilinear settings by Van Oel and Van den Berkhof [17]

Van Oel and Van den Berkhof [17] collected responses of 346 passengers at Schiphol airport, Holland. The authors recorded the responses of the passengers at the airport's

passenger area. The passengers were asked to rate their pleasure rating of stimuli. After analyzing the data, the researchers concluded that the passengers were more pleased with curved contours than rectilinear contours. There was a preference for curved contours compared to angular contours.

Both Dazkir & Read [14] and Van Oel and Van den Berkhof [17] investigated curved and rectilinear contours. Although Dazkir & Read [14] used gray scale stimuli and Van Oel and Van den Berkhof [17] used non-excluding stimuli with no isolation, Both authors discovered a preference for curved contours while measuring emotional response.

5.2 NEUROSCIENTIFIC MEASURMENT APPROACH

Very few researches have attempted to assist their preference measurements through brain activity detection. While investigating the contour preference Bar & Neta [6] attempted to assist their response with Functional Magnetic Resonance Imaging (FMRI). The stimuli that was used by the researchers were real objects or two dimensional patterns. The following part demonstrates interior settings contours through emotional and neuroscientific measurements approaches.

Vartanian et al. [18] investigated the impact of contour on aesthetic judgments and approach-avoidance. The authors attempted to create a link between architecture, psychology and neuroscience. The researchers used curvilinear and rectilinear contours. The stimuli used also included high/low ceilings and open/enclosed interior settings envelope see figure 7.

FIGURE (7): Depicts examples of stimuli that includes curvilinear and rectilinear contours with high/low ceiling height and open/enclosed interior setting stimuli [18]

The researchers tested the interior setting contour preference through two experiments that used the same test stimuli. The first experiment studied the aesthetic judgement and approach-avoidance decisions of the participants. They were asked to rate the stimuli images as Beautiful or Not Beautiful when measuring the aesthetic judgments. While the participants were asked to rate the stimuli images as Enter or Exit when measuring the approach avoidance. Curvilinear contour settings were judged more beautiful than rectilinear contour settings. In their experiment contour had no impact on the approach-avoidance.

The second experiment recorded the pleasantness ratings (from not pleasant to very pleasant) while recording the FMRI (Functional Magnetic Resonance Imaging) of the brain activity at the same time. The response of participants depicted higher pleasantness ratings for curved contours, Thus higher preference, compared to rectilinear contours. It was also found that the FMRI recorded neural activities in Anterior Cingulate Cortex ACC which is an area responsible for reward and emotional salience of objects see figure 8.

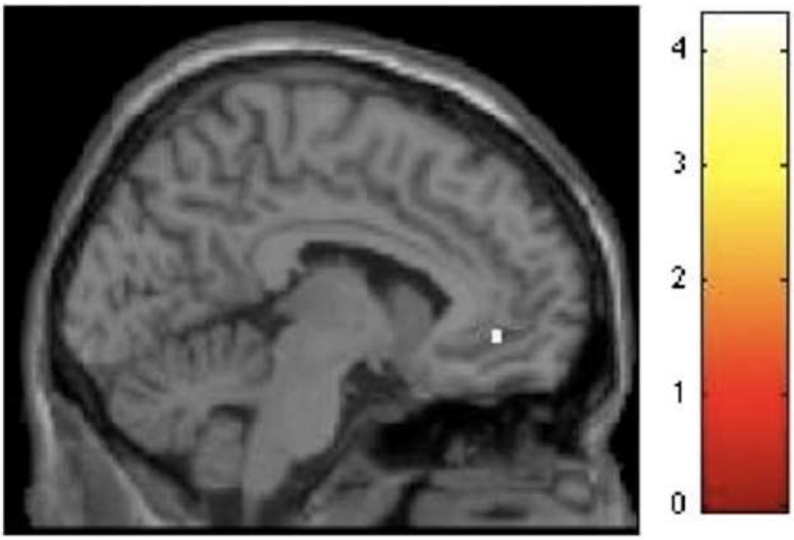

Figure (8): Depicts curvilinear contour stimuli activating ACC (Anterior Cingulate Cortex) in beauty judgments [18]

The observations in the ACC activity indicates the curvilinear contour beauty judgment and therefore preference. The researchers didn't observe any activity in the amygdala, which is responsible for threats when participants observed and rated the rectilinear contour settings. The researchers found that curvilinear contours were more preferred than rectilinear contours. The curvilinear contour settings were judged more beautiful and desired to enter compared to the rectilinear ones. They were also more pleasing and recorded neural activity in the ACC (area for reward and emotional salience of objects). In conclusion, the interior setting contour preference depicted higher curved

contour preference compared to rectilinear straight contours when measuring the response of perceivers.

Unlike all the previous studies, Banaei et. al. [19] studied interior setting and contour preference through a virtual reality built environment. The researchers noted that in order to study a three dimensional environment it is important to consider different perspectives subjected to participants. Clusters of grey scaled room interiors were modelled based on residential interior settings as seen in figure 9. Participants were asked to wear virtual reality headsets supported by an electroencephalogram EEG measuring device while walking through the virtual room as seen in figure 10 & figuree11.

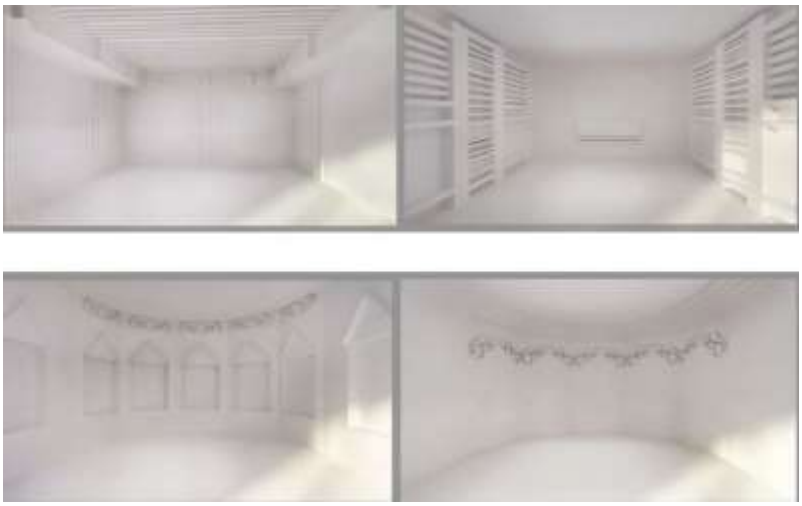

Figure (10): Depicts virtual reality modelled cluster of rooms with different contour typologies [19]

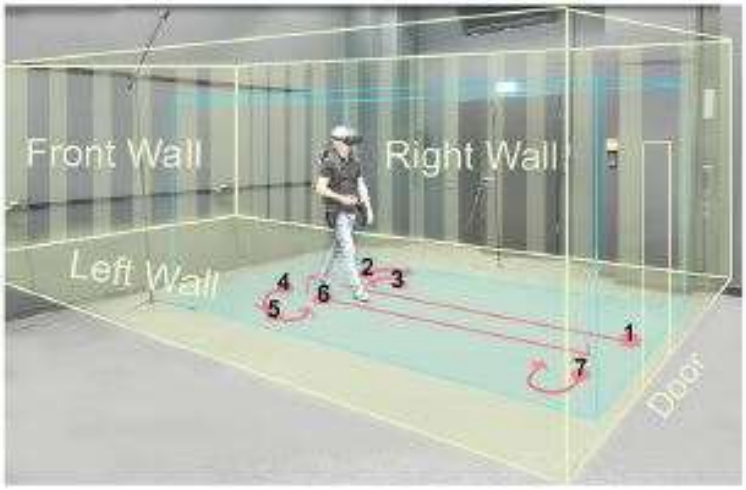

Figure (11): Depicts participants virtually walking through modelled environment while wearing Virtual reality headset supported by EEG measurement device [19]

Banaei et. al. [19] asked participants to explore the room while recording their brain activity through the EEG measurements. Participants' presence in a virtual environment was measured through a Likert scale. The researchers concluded that participants felt that the virtual environment was not correlated to a two dimensional image. As they didn't feel the presence of any two dimensional imagery which was the study base of past experiments and findings. The data extracted from the Likert questionnaire was found that the virtual environment could be more adequate than two dimensional image.

The authors found a pleasing brain activity in ACC (Anterior Cingulate Cortex) similar to Vartanian et al. [18] when participants were subjected to curved contour environments. There was a preference for curved contours compared to rectilinear contours similar to past findings [14], [17], and [18].

6. DISCUSSION

The past findings and studies, in the field of contour preference studies, investigated the contour typologies and the impact of the perceivers' response. A comparative analysis of the findings concluded that the response of perceivers depicted higher preference for curvilinear contours compared to other contour typologies as shown in table1.

TABLE 1. A comparative analysis between contour studies.

Researcher(s)	Contour Typology	Preference Measurement	Response of Perceivers	Response Reasons
Aronoff	Curved-Angular	Emotional response	Curved contours preferred than angular contours	Angular Contours gave anger and threatening feelings while curved contours gave happiness and pleasantness

Larson et. al.	Curved-Angular	Emotional response	Curved contours preferred than angular contours	Angular Contours gave anger and threatening feelings while curved contours gave happiness and pleasantness
Bar & Neta	Curved-Angular	Liking percentage - FMRI of brain activity	Curved contours preferred than angular contours	Curved contours were more liked than angular contours-FMRI depicted threat activation in brain activity to angular contours
Silvia & Barona	Curved-Angular	Pleasantness rating (1=not at all, 9=very pleasing)	Curved contours preferred than angular contours	Curved contours are more pleasing than angular contours
Carbon	Curved-Angular	Liking Percentage (Zero dislike to 100 like).	Curved Contour preferred than angular contours	Familiarity showed that participants could relate their contour preference according to design trends
Leder et. al.	Curved-Angular	Emotional response & association	Curved Contour preferred than angular contours	Curved contours are associated emotionally with positive emotional valence unlike angular contours

Munar et. al.	Curved-Angular	approach or avoidance decision	Curved Contour preferred than angular contours	Curved contours shown to be approached more by participants compared to angular contours
Bertamini et.	Curved-Angular-Rectilinear Straight	Liking Percentage (Zero dislike to 100 like).	Curved contours preferred than angular contours	Curved contours are perceived less complex than angular contours
Cotter et.al.	Curved-Angular	Pleasantness & Interest rating	Curved contours preferred than angular contours	Curved contours are more pleasing than angular contours
Dazkir & Read	Curved-Rectilinear Straight	Measuring feeling component of aesthetic emotions (Through Russell's Circumplex of emotions)	Curved contours preferred than Rectilinear Straight contours	Curved contours are more pleasing than rectilinear straight contours
Van Oel & Van den Berkhof	Curved-Rectilinear Straight	Pleasantness rating	Curved contours preferred than Rectilinear Straight contours	Curved contours are more pleasing than rectilinear straight contours
Vartanian et al.	Curved-Rectilinear	Aesthetic judgments (Beauty rating)	Curved contours preferred and	Curved contours are more pleasing and

	Straight	and approach-avoidance (Enter or Exit)- Pleasantness rating and FMRI measurement	more desired to enter than Rectilinear Straight contours	beautiful than rectilinear straight contours-FMRI measure brain activities than reflect pleasing & rewards effects when perceivers were subjected to curved contours
Banaei et. al.	Curved-Rectilinear Straight	Pleasantness rating and EEG measurement	Curved contours are more preferred than Rectilinear Straight contours	Curved contours are more pleasing than rectilinear straight contours as curved contours showed pleasantness activity in ACC through EEG measurements

In summary, the findings depicted that the curved contour preference reasons could be due to the following factors:

1- Curved contours evoke positive emotional response compared to angular contours that depicted threatening response.

2-Higher like percentages were recorded for curved contours compared to angular contours.

3-Cuvred contours are perceived less complex than angular contours.

4-Approach decisions were more associated with curved contours compared to angular contours.

5-Curved contours were found to be more pleasing and beautiful than angular contours and also more desired to be approached.

6- FMRI recorded Pleasant neural activity in Anterior Cingulate Cortex ACC evoked by curved contours compared to the threat activation in the both right and left amygdala induced by angular contours.

7- EEG detected pleasantness neural activity in ACC evoked by curved contours compared to rectilinear straight contours.

These reasons indicate a curvilinear contour preference compared to other contour typologies. Most of the researches focused on curved and angular contours in their studies. Only Bertamini et. al. [12] highlighted the rectilinear straight contour in their contour study. While Dazkir & Read [14], Van Oel & Van den Berkhof [17] and Vartanian et al. [18] & Banaei et. al. [19] investigated the curved and rectilinear straight contours in interior setting without highlighting the angular contours. Thus, the studies should include all three contour typologies in order to give a better understanding of the perceiver's responses.

Contour studies introduced important discoveries like familiarity and typicality that should be taken into consideration when experimenting stimuli. In addition emotional association should be also highlighted when testing the contour stimuli.

In the interior setting contour preference studies, the findings found the same curved contour preference when compared to rectilinear straight contours. But these studies lacked the stimuli of angular contours in interior settings. The stimuli used in interior setting were limited in number which could be insufficient in order to give a more detailed and accurate ratings. The variety of test stimuli could have also control the design factor, as individuals may perceive spaces differently even if they prefer the same contour typology.

Test stimuli should use two approaches: one while with focus on contour stimuli only and isolating other variables and another approach with these variables taken into consideration. Although Van Oel and Van den Berkhof [17] & Vartanian et al. [18] didn't isolate those variables while Dazkir & Read [14] & Banaei et. al. [19] used gray scaled renders that controlled these factors, they reached the same results. Although the contour studies isolated the contour variable through using simple drawn shapes, simple lines or sceneries perceived, daily items and objects, novel patterns, symmetric shapes and irregular complex shapes, the study of the interior space morphology requires more intense contour iteration and form generation. Therefore, the results of contour studies could only act as an indicator for the response as further studies will be required in the interior setting contour preferences in order to give a better understanding.

All of the findings in contour and interior setting contour preferences studied the contours and the contour typology without taking into consideration the contour features. One of those important features is the Contour Quantity & Repetition. In

addition, the interior setting contour findings used stimuli with no relation to a Space Function. As participants perceived spaces but didn't consider in mind the function or activity of the perceived space. These notions should be highlighted in order to reach a more accurate conclusion.

7. CONLUSION AND RECOMMENDATIONS

The response of perceivers when subjected to curved contours in an isolated state or in an interior setting would depict more preference by perceivers compared to other contour typologies (angular contours or rectilinear contours). Curved contours is always rated more beautiful, more liked compared to other typologies.

Further studies in interior setting contour preference should take into consideration: the iteration and amount of test stimuli, variables' control (control of light, color and texture), contour typologies (curved, angular & rectilinear straight contours), the contour quantity & repetition and the space function. These considerations could provide more comprehensive and intense results.

Space perceivers would judge curved interior settings more pleasing and beautiful than angular or rectilinear contours. Angular contours are more interesting to space perceivers than other typologies. Curved contours indicate a more calm and positive environment compared to the angular contours that provide a more threatening emotions and feelings. When designing spaces with meanings, architects and designers could manipulate the interior space morphology through using curved or angular contours to create an interior experience.

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