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Exploring Mondrian Compositions in Three-dimensional Space

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Abstract

The dogmatic nature of the Neoplasticism manifesto initiated a discourse about translating aesthetic ideals from paintings to 3D structures. Piet Mondrian rarely ventured into architectural design, and his unique interior design of ‘Salon de Madame B... à Dresden’ was not executed. We discuss physical constraints and perceptual factors that conflict with Neoplastic ideals. Using physical and virtual models of the ‘Salon’, we demonstrate challenges with perspective projections, and how such distortions could be minimised in a cylinder. The paradoxical percept elicited by a ‘reverspective’ Mondrian-like space, further highlights the essential role of perceptual processes in reaching neoplastic standards of beauty.

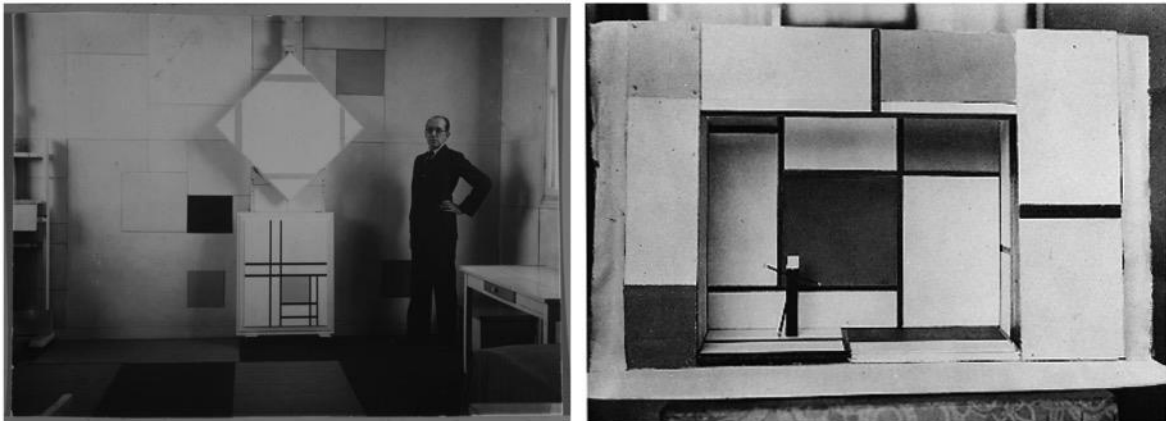
Introduction

The Dutch painter Piet Mondrian (1872--1944) was one of the founding member of the Amsterdam De Stijl art movement. This group of painters, sculptors, architects, and poets interacted closely with the Bauhaus art movement in Germany and Russian avant-garde. Mondrian developed his own characteristic style of ‘neo-plastic abstraction’ [1] which aspired to capture ‘pure beauty’ by the use of lines and basic colours in ‘pure relationship’ [2]. Mondrian proposed six ‘neoplastic laws’ of aesthetics in his essay ‘Neoplasticism in Pictorial Art’ [3], one of which instructs the use of cardinal orientations for lines and rectangular shapes to achieve constant equilibrium. The first, somewhat lofty and warped manifesto was published in De Stijl journal in 1918 [4], which proclaimed a new, universal and abstract aesthetics that is no longer restricted by forms observed in nature.

A key debate about universality of neoplastic aesthetics focused on how painting relates to architecture. The crucial goal was to develop architecture beyond its technical (engineering) and decorative (crafts) aspects into a genuine art form, encapsulated in the Dutch term ‘bouwkunst’, where the aesthetic statement is no longer constrained by physical limitations [5]. Mondrian [6] sees the interior as an enclosed space, as an artistic object that should follow the same ‘pure’ principles to create equilibrium; putting beauty above utility. Many of these ideas are presented as intuitive claims, such as the need to overcome dependence on perspective that is inherent to architecture [7].

Mondrian’s paintings - rectangular grids of black lines on white ground and rectangles filled with primary colours, undoubtedly belong to the icons of 20th century arts. The catalogue of his works, [8], shows 83 distinctive patterns of pure abstraction between 1920 and 1941, many as variants of the same basic design [9]. Mondrian’s passing interest in interior design is shown by intentional staging of his paintings in his studios [10]. Following manifesto goals towards inseparable aesthetics of art and life, he purposefully arranged paintings, colour plates and pieces of furniture in his studios, locked to a specific camera viewpoint (Fig. 1A). In his Paris studio he even worked around an oblique wall by placing occluders [11]. Inspired by Seuphor's Dada play ‘L'Ephémère est éternel’, he designed a stage set with a frame facing

the audience in the foreground and exchangeable backdrop scenes painted in his iconic style. A scale model of this austere proscenium could be found in his studio in 1926 [12] (Fig. 1B).

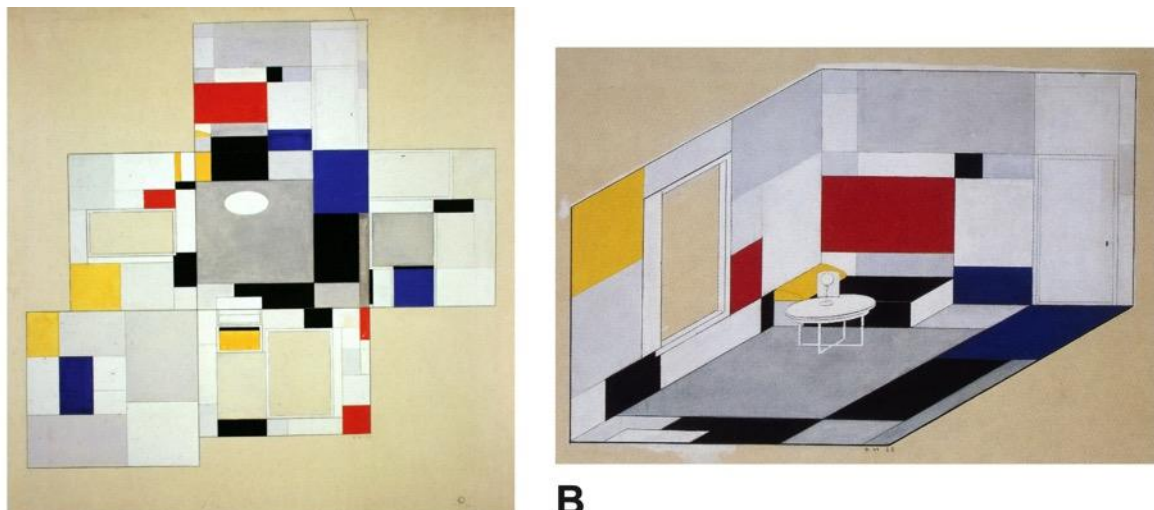


A

B

Figure 1: (A) Mondrian in his studio in 1933 by Charles Karsten; Image credits: Collection Het Nieuwe Instituut/ KARS, E3.238-2. Note that the lines on the diamond-shaped painting in the centre of this photograph shows an emphatic arrangement of horizontal and vertical lines creating the outline of a truncated square shape as emphatic statement supporting the ideal of cardinal lines (see VSAC 2016 abstract). (B) 'L'Ephémère est éternel', 1926; Image source: The Mondrian/Holtzman trust

A unique example of Mondrian's architectural thinking is an exploded box plan and axonometric drawings for a 'Salon de Madame B... à Dresden' (the 'Salon') from 1926 (Fig. 2). He was commissioned in 1925 by his patron Ida Bienert for the 'Damenzimmer' in Dresden to become a library and study. The initial version of this plan, kept by Mondrian, was a black and white drawing with colouring instructions [13]. We use here the coloured version of the plans from Bienert's estate [14] held in the archives of the Dresden State Art Collections museum.



A

B

Figure 2. 'Salon de Madame B... à Dresden', 1926 (Holler & Schnitzer, 2004) (A) Exploded box plan (B) Axonometric plot: the floor and two walls are assembled such that they can be seen in a perspective from 30 degrees from the left wall and 30 degrees from above; no perspective foreshortening. Image source: Staatliche Kunstsammlungen Dresden

Mondrian never did see the ‘Salon’ being completed. In 1970 it was reconstructed in the Pace Gallery, New York and this prompted questions why the plans were never realised [15]. The original drawings show some rudimentary pieces of furniture [16]; and there is no indication how paintings from Bienert’s art collection would be placed. These details might indicate fundamental issues with the translation of these drawings into three-dimensional space. Mondrian’s firm commitment to cardinal line orientations on planar surfaces would create issues with decorating a cuboid while allowing multiple viewpoints.

The purpose of this paper is to explore the role of perceptual mechanisms in an attempt to resolve the apparent conflict between Neoplastic dogmatic ideals and projective geometry. To this end, we present three demonstrations: (1) a scale model of the ‘Salon’ that highlights how the corners of the room affect the picture projected on the observers’ eyes; (2) a computer graphics (CG) simulation of being in such space, and an alternative configuration that would avoid corner effects; (3) a physical model of a space in Mondrian-like patterns that create surprising depth illusions; demonstrating perceptual conflict of these patterns with the geometry of surfaces.

A physical model of Bienert’s Salon

Although Mondrian mentioned in letters that he was experimenting with the design for Ida Bienert, and might even build a scale model [17], it was not realised in his time. In order to get a better idea about how this salon might have looked, we constructed a ‘shoebox’ model (Fig. 3) by following Mondrian’s drawings (Fig. 2A).



A **B**
Figure 3. The ‘Salon’ scale model: (A) Birds eye view into the ‘shoebox’ with a fisheye lens; 289 x 304 x 125 mm (L x W x H), ceiling removed. (B) Diagonal view into the ‘shoebox’ with standard camera lens (‘shoebox’ rotated by 45 degrees relative to left image), two front walls removed. (© Jasmina Stevanov and Johannes M. Zanker.)

It is obvious that in the image plane, horizontal lines on the walls intersect in the corners at oblique angles; as would be expected in projective geometry. Mondrian’s dogmatic proclamations [18] to use exclusively cardinal lines in 2D context (paintings) could be challenged when his patterns are placed in a 3D context; his ‘L’Ephémère est éternel’ stage set could be regarded as the only viable solution where observer’s viewpoint is restricted to a frontoparallel inspection. In a cubic room, however, the observer is allowed to look from a wide range of viewpoints at the patterns on the walls. Although the room is faithfully constructed to doctrine, in the static retinal image, comparable to a snapshot, the lines on the

walls would deviate from cardinal orientations. For demonstration purposes, this is shown as the projection onto the camera lens in a photograph of the ‘shoebox’ model (see Fig. 3B; cf. to Fig. 2B).

Mondrian created axonometric drawings of the salon as seen from 30 degrees above floor level and from the left. They show a clear deviation from the rectangular doctrine: oblique lines in the vertexes of the room. In the axonometric plot (Fig. 2B) horizontal lines on the wall remain parallel, whereas they are oblique in the ‘realistic’ photography (Fig. 3B), as a result of natural perspective [19]. In G. Vantongerloo’s representation of a similar room (see [20]), there are signs of foreshortening --- it appears that these artists were struggling with the attempt to preserve parallel lines.

CG visualisations of Mondrian’s interior design

Mondrian’s axonometric plots assume an observer position outside the room. We created a 3D model of the ‘Salon’ in LightWave3D (NewTek Inc. 2013) to simulate experiencing the real ‘Salon’ and also to remove walls to render an inside look for any given viewpoint. Mondrian’s original drawings show that the space was divided into rectangles filled with primary colours, white, and several shades of grey (which were abolished in his later paintings). Interestingly, lines were largely reduced to boundaries between rectangles, nothing like the thick black lines in his paintings [21]. We created a CG ‘Salon’, without rectangle outlines as in Mondrian’s original drawings (Fig. 4). The other variant has heavy lines, more true to his iconic style (Supplementary A). We assumed that the height of doors is 2m; using proportional scaling the salon dimensions approximate to 4 x 3.6 x 3 m (L x W x H). The key observations are illustrated with five still frames showing the view captured in 45 deg rotation intervals (Fig. 4C).

The ‘Salon’ with prominent cardinal lines demonstrates that oblique converging lines are very strong cues to depth perception and facilitate the shape constancy; the latter is difficult to maintain under high uncertainty about the shape, perspective, and inclination of surfaces in linear perspective [22]. A trapezoidal shape can be seen both as a trapezoid on a frontoparallel plane or as a slanted rectangle (Fig. 5). However, the correct perspective interpretation of the room is enhanced by the motion parallax information provided in animations.

Mondrian patterns can be unambiguously perceived only if the line of sight is perpendicular to the walls of the ‘Salon’ (Figures 4, panels C(1,3,5)). The strongest perceptual ambiguity, distortions of rectangular shapes and non-cardinal orientations, can be seen in the static retinal image of vertexes of the ‘Salon’ (Fig. 4, panel C(4)). Prominent black lines would facilitate shape constancy of rectangles from a range of vantage points; while at the same time more robustly violate the Neoplastic dogma. On the other hand, distortions of rectangles in vertexes are more pronounced without thick black lines, as they are more likely to be interpreted both as trapezoids and rectangles (Figure 4, panels C(2,4), Supplementary A).

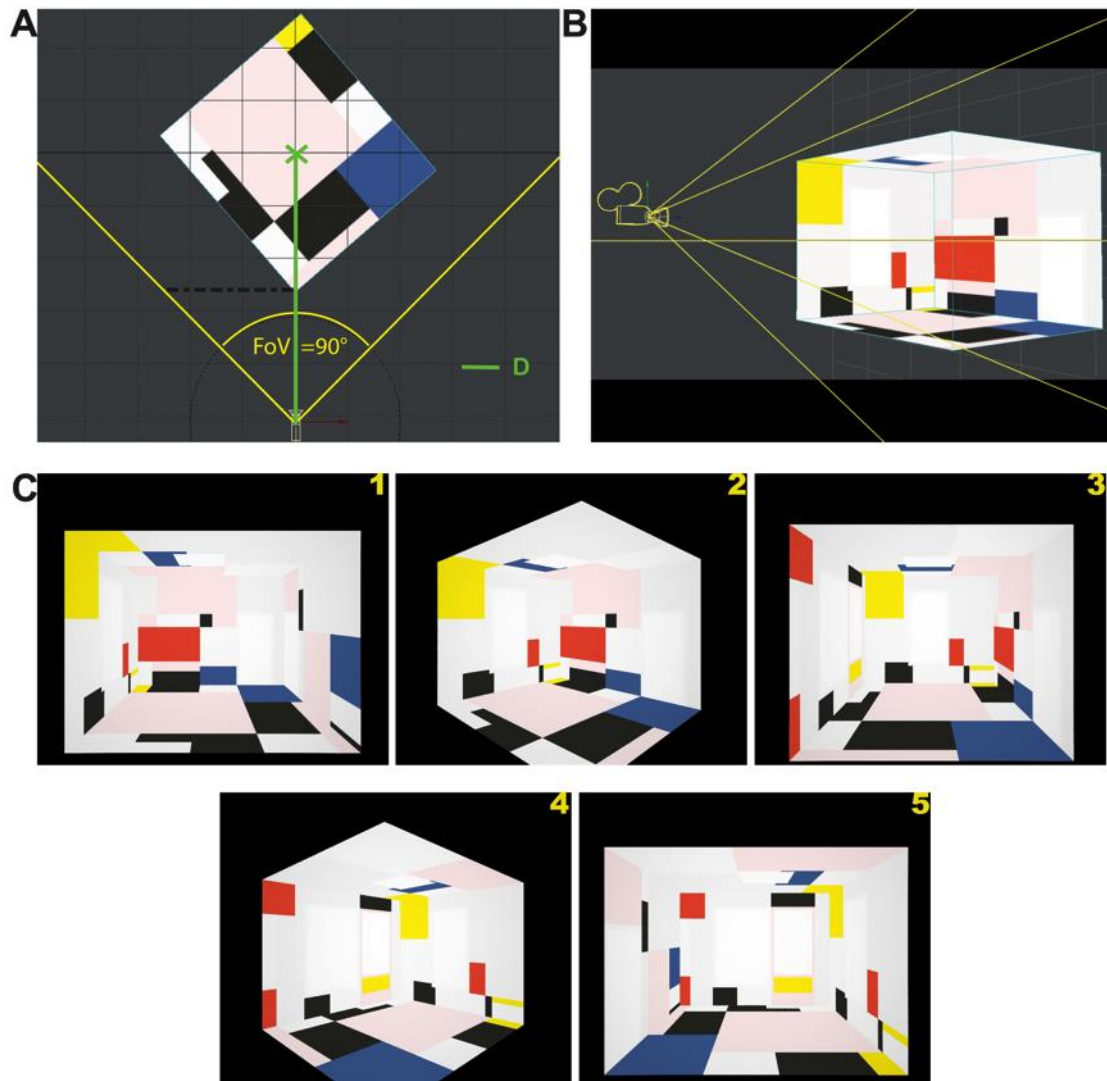


Figure 4. CG model of the Mondrian's 'Salon' using patterns without prominent cardinal lines: (A) Geometry in top view: field of view (FoV) was 90 deg horizontally and 53 deg vertically; viewing distance D set to the length of the longer diagonal of the floor area; (B) a perspective view of the scene layout; (C) camera view of three walls (C: steps 1, 3, 5) and two corners (C: steps 2, 4); C2 corresponds to the viewing angle in Fig. 3B. (© Jasmina Stevanov and Johannes M. Zanker.)

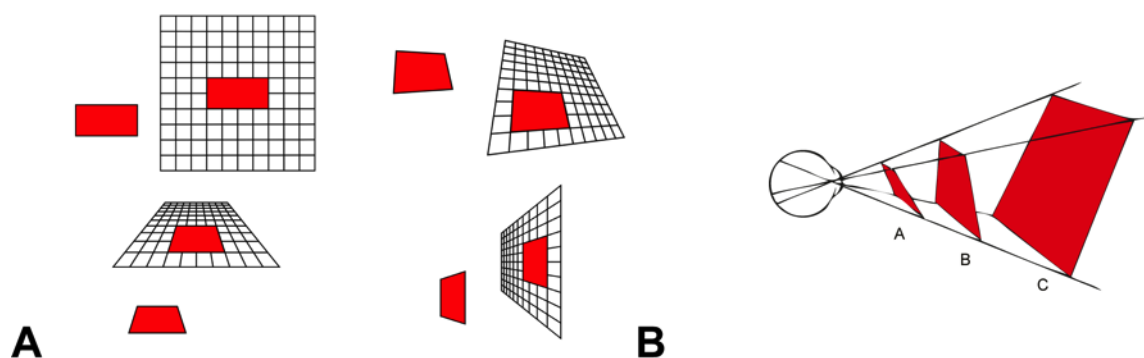


Figure 5. Ambiguity of converging lines: (A) without oblique converging lines suggesting perspective planes, a trapezoid can be seen both as trapezoid in the frontoparallel plane and as a slanted rectangle belonging to another perspective plane (picture adapted from [44]); (B) Joint ambiguity of shape and perspective; shape constancy is difficult to maintain if estimated from inclination in linear perspective (Image adapted from [45], p.139). (Image used by permission of Oxford University Press, USA.)

Non-cardinal orientations and distortions of rectangular shapes can be avoided in a room without corners, such as in a cylinder. We created a CG model of a cylindrical room with the same overall dimensions as the ‘Salon’ (Fig. 6, Supplementary B). The four walls of the Mondrian’s ‘Salon’ were mounted on the circular wall next to each other. Instead of modifying the ceiling and floor of the ‘Salon’, to fit onto the circular base of the cylinder, we simulated a mirror surface to perceptually expand wall patterns across the ridge of the cylinder (Fig. 6B).

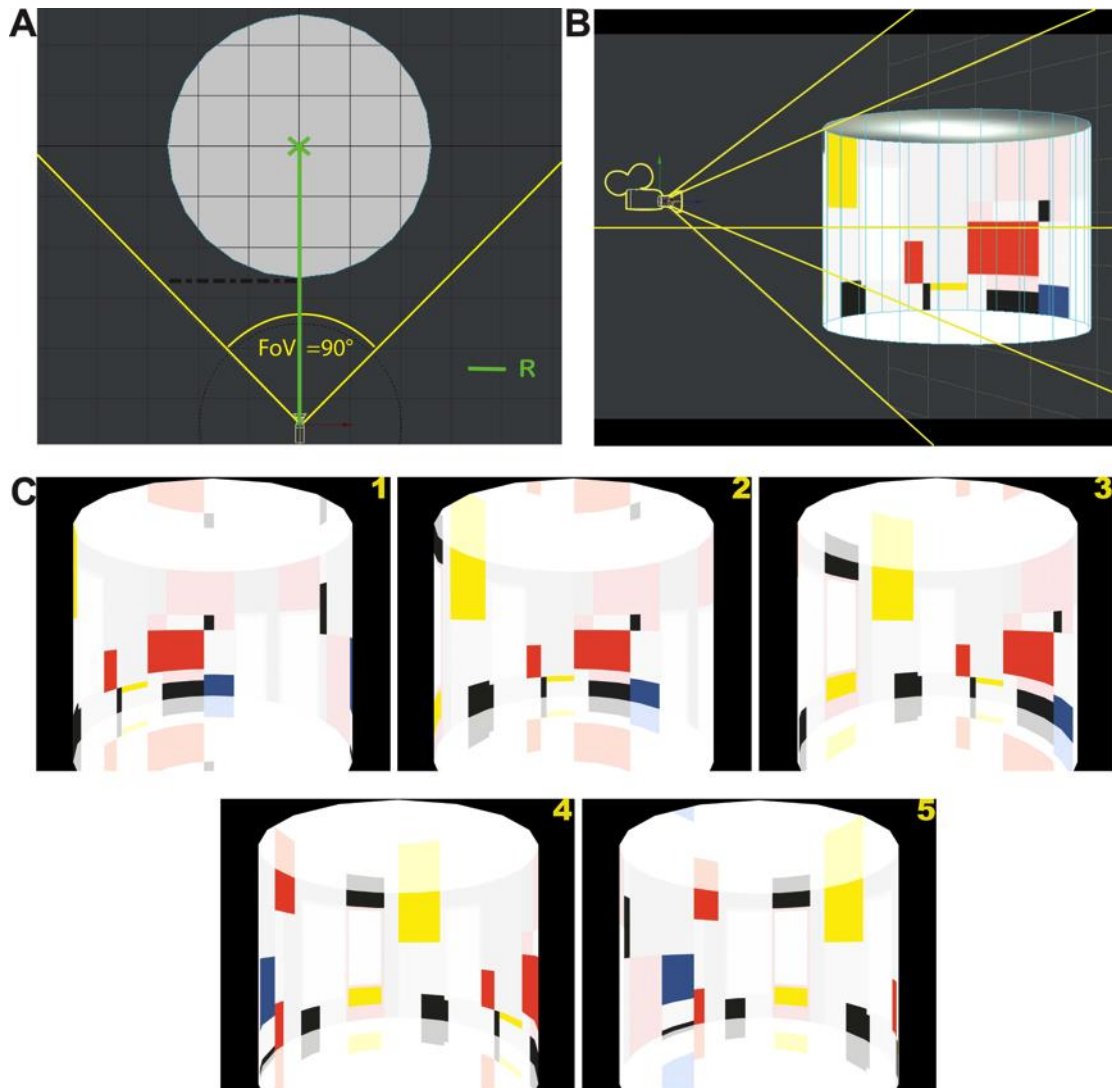


Figure 6. CG model of the Mondrian-like cylindrical ‘Salon’ without prominent black lines. A view at the cylinder from outside: (A) Geometry in top view: FoV was 90 deg horizontally and 53 deg vertically; viewing distance R set to the length of the cylinder diameter; (B) a perspective view of the scene layout (C) (1--5) still frames from the animation, step 2 corresponds to the viewing angle in Fig. 3B. (© Jasmina Stevanov and Johannes M. Zanker.)

In the cylindrical room there are no vertexes, thus the most obvious conflict with Neoplastic composition rules is removed. Throughout the field of view (FoV), vertical lines on the cylinder appear strictly vertical. With half of the cylinder being in the FoV, however, horizontal lines only appear horizontal in the centre, but bend upwards and downwards in the periphery deviating from orthogonality. These peripheral distortions persist in conflict with Mondrian’s ideal, which is further enhanced by more prominent black lines (Supplementary B).

The sense of a rectilinear composition could be enhanced by restricting the FoV, for instance by getting closer to the wall ahead. Within a smaller region of the wall, the number of visible rectangles and lines is reduced, raising the question whether the remaining pattern would still be compatible with the typical Mondrian composition. The analysis of his paintings layout [23] created between 1925--1935, reveals that the average number of lines was 5.2, while the number of rectangles was 5.5; in images of 52 x 58 cm average size. This means that the number of elements on the wall pattern would need to be inversely proportional to the FoV, by reducing the size of rectangles and increasing the number of elements on the wall. Our hypothetical pattern in a narrow FoV may be alternatively considered in terms of neoplastic doctrine; albeit it is clear that aesthetic tensions cannot be completely resolved.

Using CG models and animations was useful to demonstrate possible issues with Neoplastic aesthetic rules arising from different viewpoints [24] and geometry [25] of the real world. Most importantly, these animations demonstrated how perspective cues from static images and dynamic cues from motion parallax [26] interact in 3D perception. These mechanisms have a long evolutionary history - they can even enable insects to discriminate 3D shapes [27], suggesting that no high-level cognitive processing is needed to interpret the shapes of objects in space. In the following section, we will demonstrate how the same mechanisms that enforce shape constancy and veridical space perception cannot always resolve perceptual ambiguity of static (pictorial) and dynamic (motion-parallax) depth information.

Mondrian composition in reverse perspective

Trapezoidal shapes in photographs at the corners of objects are typically perceived as representations of rectangles, due to shape constancy; in an extreme case this creates a conflict with motion parallax information that generates paradoxical experience of a room following the observer sidewise [28]. Following the work of Patrick Hughes [29], we constructed a model in 'Reverspective' space: Mondrian-like patterns were morphed on the surfaces of two capped pyramids with a square base ('square frustums'), so that the original pattern rectangle was stretched to fit into the four isosceles trapezoids of the frustums (Fig. 7B).

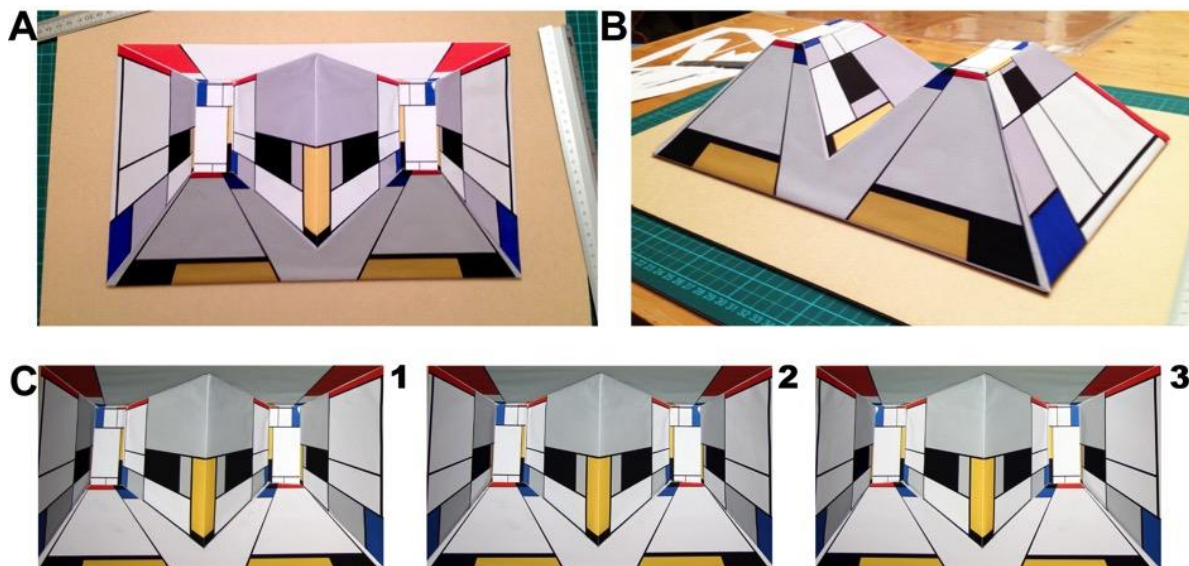


Figure 7. 'Reverspective' Mondrian space: two square frustums with morphed Mondrian patterns made of four paintings: [46] catalogue numbers and years 129 [1921], 142 [1922], 210 [1929], 216 [1929]; (A) perceived as two concave corridors when seen from above; (B) seen as two capped pyramids from a side; (C) Three still images from the animation showing illusory rotation in 9 deg steps. The camera was at 90 cm from the model and it captured 12 frames, each displaced by 2 cm. (© Jasmina Stevanov and Johannes M. Zanker.)

Seen from the apex at a distance (reducing binocular depth cues), the frustums are perceived as concave boxes or corridors (Fig. 7A, Supplementary C). Based on perspective cues the shorter lines at the apex appear more distant than the longer lines at the base. However, if observers move their head laterally, closer regions at the apex move faster across the retina than more distant regions at the base, which creates paradoxical illusion of a rectangular corridor following the observer [30],[31]. Perception is biased towards the most likely interpretation by shape constancy mechanisms. Lines can be perceived as parallel and orthogonal when they are part of slanted trapezoids; and equally when they are part of a tilted rectangle as in the ‘Salon’. Because the retinal images would appear equal, the interpretations of the retinal images are equal: lines are seen as parallel and orthogonal. The ‘reverspective’ model demonstrates how robust is ‘shape constancy’ mechanism. Similarly, different viewpoints for Mondrian patterns would hardly disrupt our stable perception of cardinal lines in the ‘Salon’. Could this demonstration cast new light on Mondrian’s design of the ‘Salon’?

Discussion

The problem.

In his discourse with De Stijl, Mondrian [32] published his plan for a ‘Salon’ to illustrate his vision of Neoplasticism architecture: a fusion of many simultaneous planes into a balanced 3D object. The fact that the ‘Salon’ was not realised could have been due to logistic and financial reasons, but also could reflect his dissatisfaction with dependence on perspective and laws of projective geometry. We demonstrated that vertexes in the ‘Salon’ might be in conflict with the Mondrian’s ideal of cardinal lines and suggested that unwanted distortion could be reduced in a hypothetical cylindrical room. The latter could provide a partial work-around, but would remain far from a universal guidance for neoplastic architecture.

A proposition.

In the 19th century, scientific understanding of subjective human experience emerged with the advance of experimental psychology and the new discipline of psychophysics [33]. An idea to study beauty by focusing on basic forms and relations was already pioneered by Fechner and his reductionist ‘aesthetics from below’ [34], studying colours and simple geometrical shapes as stimuli that could be precisely controlled and manipulated. In the 20th century, Gestalt Psychology provided comprehensive insight in perceptual representation [35], which has influenced the development of a ‘vocabulary of pictorial representation’ in arts [36]. Early claims about the relevance of psychophysics for aesthetics [37], however, attracted surprisingly little attention. The scientific approach was embraced by some members of the Bauhaus [38], and although Mondrian interacted with the Bauhaus [39] he seems not to have taken particular interest in scientific evidence.

The conflict between the neoplastic ideal of beauty and the human interpretation of the 3D world results from a direct interpretation of static retinal images. However, oblique distortions in the retinal images are corrected by perceptual mechanisms (e.g. shape constancy) generating veridical perceptual representations of space [40]: The characteristic relationship between physical space, the rules of perspective for a given viewpoint, and their effortless 3D interpretation from projections on a single plane, are well understood. We used a reverspective object here to demonstrate how the mind makes sense of the outside world in the presence of conflicting depth cues.

Five years after publishing the Neoplasticism manifesto, Mondrian pointed at a mysterious way of the mind to detach from the physical body: “man’s eye is not yet free from his body

... only the mind knows anything of the fourth dimension and detach itself from our poor physical bodies” [41], p 13 in [42]. Could this be a hidden or unintended hint at relaxing the composition rules taking into account mental representation? A scientific framework can put some of his comments about the future of architecture into a new perspective.

Mondrian strictly believed that universal beauty could be defined solely by properties of objects. A century later we think that aesthetic judgement arises from the interaction between object features, properties of our visual system, and processes of value attribution (for review, see [43]). Whilst the corners of the ‘Salon’ might have frustrated Mondrian’s appetite to work on perspective challenges, we propose a simple solution: aesthetic judgement should be based on our perceptual representation rather than static retinal images. Another rather crude alternative would be to accept that the Mondrian-type space is just not beautiful as it falls short of strict Neoplastic ideals of beauty. Although Mondrian-type space may not have been considered as beautiful at the beginning of 20th century, we should not easily adopt that verdict in the 21st century --- after all, the beauty is not in the eye, but in the mind of the beholder.

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ⁱ It is interesting to note that some of the transformations that Mondrian made on his paintings (Cooper & Spronk, 2001) can be interpreted as an introspective experimentation with his composition scheme, which resembles the manipulations in an experimental study of his style half a century later (McManus et.al. 1993).

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